COMMITTEE REPORTS NUMBER

# ELECTRICAL WEST

WITH WHICH IS CONSOLIDATED
THE JOURNAL OF ELECTRICITY

A McGraw-Hill Publication

MAY 15, 1931

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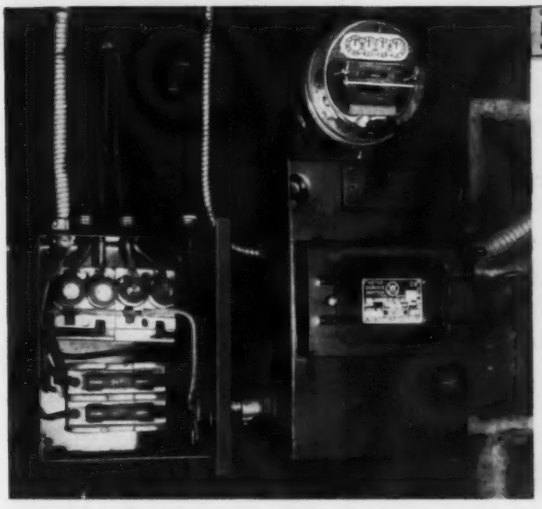
FLIPONS
*make homes*
FUSELESS

*The New Way*—as easy to restore service as to operate a wall switch.



*The Old Way*—This cumbersome installation can now be replaced by the neat, compact No-fuze Load Center shown in the upper photograph.

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**Westinghouse**

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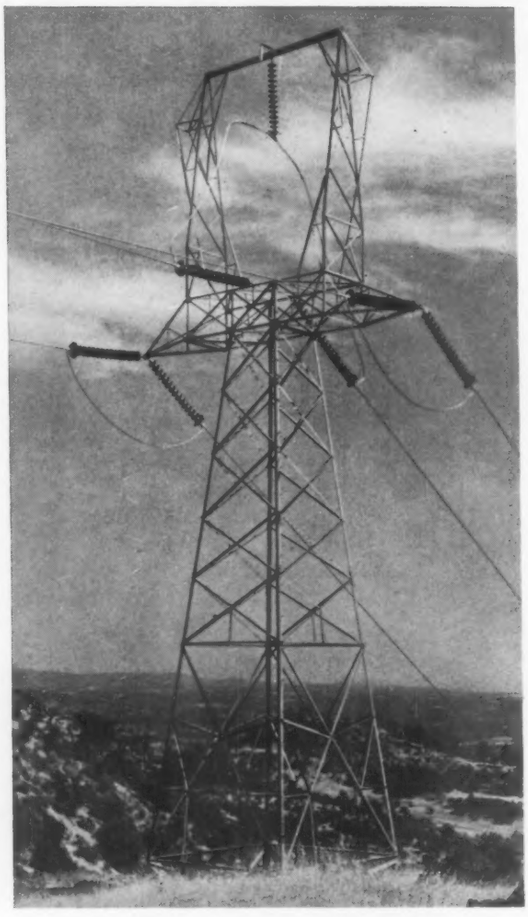

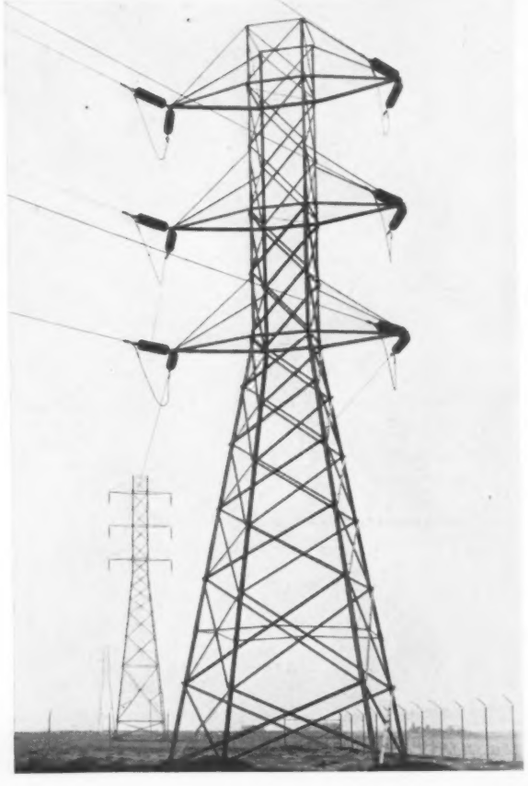

# The TREND toward Steel Transmission Towers

WITH transmission at higher voltages and the growing demand necessitating increased capacities, the trend toward Steel Transmission Towers is becoming more and more pronounced. Where formerly single-circuit high-voltage transmission lines supported on wooden structures were practicable, today most companies have found it imperative, because of the increasingly large amounts of power transmitted, to adopt the use of two-circuit steel towers for their main transmission lines.

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*Los Angeles*: Pacific Finance Building

*Export Distributor*: Bethlehem Steel Export Corporation, 25 Broadway New York City

**PACIFIC COAST STEEL CORPORATION**

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## Ideas that 'click'

Your customers have money to spend but they are careful how they spend it. While this condition exists you should seize upon every opportunity to use ideas that click with the buying public.

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# HAMMOND

ELECTRIC CLOCKS

ELECTRICAL WEST

With which is consolidated the Journal of Electricity
*A McGraw-Hill Publication*

San Francisco, May 15, 1931

Volume 66
Number 6

G. C. TENNEY, *Editor*

# A Post-Graduate Course

THE man who believes that his education ceases when he finishes his schooling has no interest in this issue of ELECTRICAL WEST. Neither has he any interest in his job, his profession or his industry. He is the laggard, the fault-finder, the complainer. His job is a rut from which he will never climb. Fortunately such men are in the minority.

TO those other thousands of men who are searchers after knowledge, who know that when diplomas are received from high school or college their education has just begun, this issue of ELECTRICAL WEST is dedicated. The editorial content of this issue was written by their fellows, eight hundred of them, earnest, hard-working committee men of the Pacific Coast Electrical Association and the Northwest Electric Light and Power Association.

IN the following pages are reports covering a year's research, study, analysis and discussion of the most serious problems confronting the light and power industry. Countless committee meetings have been held, letters exchanged. Midnight oil has been burned that these reports might be produced. Here is a record of progress, a summary of mistakes made, recommendations for future practice, reports of experience—all prepared so that the industry may advance and develop.

LET the executives who question the value of association work simply glance through the headings. If after doing so they regret the time spent by employees at committee meetings and conclaves, or the money contributed to the associations, then their right to the title of executive is open to question. It is safe to wager that they will be convinced that even they are not benefiting to the fullest possible extent from association activities.

ASSOCIATION work plus the business and technical press constitute industry's post-graduate universities. He is a wise man who reaps the utmost benefits from both. He is the man who studies that he may have a better grasp of his own job, that he may profit by the experiences of others. He is the man whose progress is assured, to whom advancement comes as a matter of course.

SUCH a man does not need to have this issue commended to his attention and study. As for the others—well, they do not matter.

# Constantly Improving Our Service to the Consumer

By A. M. FROST

FOR some years now, our themes for Pacific Coast Electrical Association administrations have been along the lines of "more kilowatts per consumer," "more revenue per dollar of investment," and ideas of that sort. This year we decided that the consumer should have his innings.

After all, he is the one who pays the bills which create the revenues. He uses the kilowatts. In the face of more serious competition with other industries for the consumers' purchasing power, it is well that the electrical industry should take stock of itself and see its product is in keeping with what is expected of it. Which is a great deal! Is the service improving constantly? We all feel that it is, but let us check up and make sure.

This has been no easy year for any industry. The records of meter readings among our industrial customers look like snail tracks. In some plants the meter readers may well have wondered if the little disk that is supposed to revolve had been nailed down. Yet despite this fact the total use of electricity has not materially decreased. The home folks have come to the rescue.

Domestic customers, then, have tasted the comfort and the convenience and the cleanliness of electric lighting, cooking and heating. They have learned to enjoy and to rely upon their radio and their various appliances. Other items of the household budget may be curtailed, but this bargain in comfort which we sell them they give up last.

*A. M. Frost*

President Pacific Coast Electrical Association

The home customers, therefore, have saved our industry from the great slumps which have hit other commercial enterprises. It is only right then, that we should have more to offer to these home consumers for their dollar than ever before. We owe the domestic consumer constantly improved service. We are going to see that he gets it.

In agriculture as well as in industrial plants, power use has suffered in step with the losses in these industries themselves. Our greatest immediate problem is so to improve our service to these classes of customers that electricity will be one of the greatest aids they can employ to restore their business to them. Fortunately, in a young and inventive industry such as this, there has never been so much as there is now to offer in the way of improved design and new products and machines for farming and factories.

Our engineers not only have caught up with the demands for power and for the machines and devices to put electric energy to useful purposes, they have anticipated tomorrow's demands for automatic and super-accurate devices. Thus we now have these equipments available for improving the service of electricity to the public.

If this coming summer proves to be an exceptionally dry one, as present signs would indicate, the engineers of our companies and their construction crews have prepared for it. There is more than ample steam reserve to meet all the needs. But steam power sometimes costs a little more to produce than hydro. This throws on the sales and other departments of light and power companies an added responsibility. Existing lines and facilities must be used more in order to earn enough to offset the higher generating and operating costs.

More use, more revenue—both of these depend on the creating of more usefulness, more value to the customer—and then telling him about it.

During times of trouble there is a tendency to let down. Discouragement breeds inactivity—and inactivity dulls the alertness which is so necessary to a maintenance of high standards of service. If we let ourselves go, the product we have to offer to the public will depreciate. Instead of having more to sell for the money, there is danger we may deliver less.

Therefore, if ever there was a time when every man, woman, and office boy in the industry needs to be on his toes, needs to extend himself to the utmost, it is now. Of all industries in the country we can least afford to relax our vigilance in giving oversize extra-ply service. There should never be anything shoddy in electrical values. There doesn't need to be. Electricity is still the biggest bargain in all America.

"Constantly Improving Our Service to the Consumer" is no idle mouthful of words. This year and next it is a challenge to deliver the goods.

# Accounting Section[1]

## *Construction Accounting**

***Due to the many and varied conditions obtaining in the field, it is particularly important that systematic accounts be kept and an orderly procedure maintained. The following report covers methods used by many of the member companies. It should be regarded as merely preliminary.***

AS in all lines of endeavor, orderly and systematic procedure must obtain. This is particularly true of construction, due to the many and varying conditions that are constantly encountered in all phases of this work. Before organizing for actual field work, a carefully laid plan of procedure should be laid out. A suggested accounting procedure chart is illustrated in Fig. 1.

In the handling of construction, concise and complete accounting instructions, which are applicable for any type of work, are necessary to both foreman and field clerks. It is

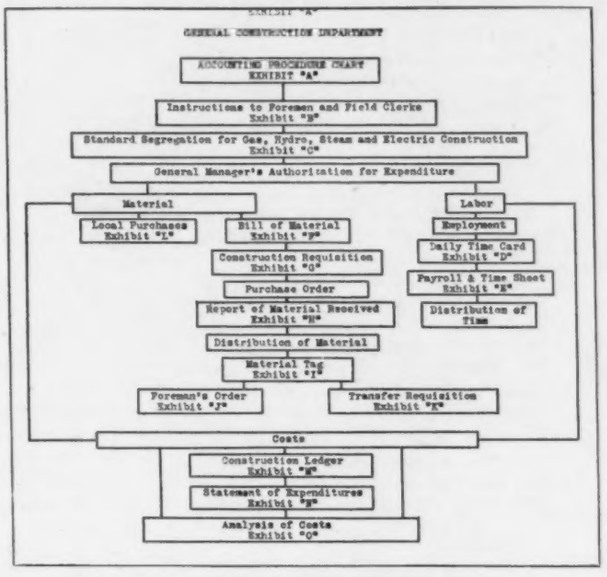


*Fig. 1. Chart of suggested accounting procedure.*

thought that a standard set of instructions should be issued, which should embrace timekeeping in all its phases, operation of boarding houses and commissaries, method of ordering material and its distribution, handling of salvage, compilation of different kinds of progress reports, etc. At the present time only one of the affiliated companies is using such an instruction book.

The index page, alphabetically arranged, of this instruction book covers the following subjects:

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---

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---

* Report of committee on construction accounting, Accounting Section. E. E. Dodge, Pacific Gas and Electric Company, chairman.
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Southern California Edison Company Ltd.: V. White.
The Southern Sierras Power Company: L. B. Reed.

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## Segregation of Accounts

It was found that there is no uniformity in the accounts and items that are used on construction projects. Some companies have developed items in conformity with the California Railroad Commission classification; others have developed their own standard accounts which are uniform on all types of construction; while others use items taken at random for each individual piece of work.

It is hoped that a standardization can be compiled covering all classes of construction, irrespective of whether it be transmission, distribution, substation, or hydro. The same relative classes of work should have the same items allotted to them. In the final analysis, the capital account number can be allocated for capitalization purposes. This makes it possible for field clerks, foremen, mechanics and workmen to familiarize themselves with standardizations and have only one item for each class of work. We also suggest that standard units be used, which permit ready comparison between like types of work. For instance, all pole line construction would be recorded under items No. 530 and No. 540, irrespective of voltages or locations.

A tabulation of this suggested standardization of items and units follows:

GENERAL CONSTRUCTION DEPARTMENT
STANDARD SEGREGATION
FOR
GAS, HYDRO, STEAM AND ELECTRIC
CONSTRUCTION

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| 540 | Pole Line Conductors and Insulators | 38, 39 |
| 560 | Public Outdoor Lighting | 39 |
| 570 | Consumers' Meters | 39 |
| 580 | Telephones | 39 |
| 590 | Miscellaneous Construction Expense | 40 |
| 600 | Permanent Roads, Trails, Bridges and Board Walks | 40 |
| 610 | Permanent Tools | 40 |
| 620 | Furniture and Fixtures | 40 |
| 630 | Replacement Expense—Hydro, Steam and Electric | 40 |
| 640 | Maintenance Expense—Hydro, Steam and Electric | 41 |
| 650 | Operating Expense | 42 |
| 660 | Replacement Expense—Gas | 42 |
| 670 | Maintenance Expense—Gas | 43 |
| 1000 | Engineering, Superintendence and Accounting | 43 |
| 1010 | Construction Plant, Warehouse, Etc. | 43, 44 |
| 1020 | General Overhead Expense | 44 |
| 1030 | Clearing Accounts | 45 |

EXTRACT FROM STANDARD SEGREGATION FOR GAS, HYDRO STEAM AND ELECTRIC CONSTRUCTION

260 *High Tension From Line Side of Switches to Transformer Structure*—

This includes air and oil switches, current and potential transformers, fuses, brackets, buses, and all supporting structures from line side of switches up to the transformer bus structures including painting.

Any electrical control wiring of these switches, or instrument wiring from current or potential transformers should be charged to "A.C. Control and Main Connections" item. Switchboard panels controlling these circuits will be charged to item 300. All ground wiring and ground buses for metering purposes, if not on switchboard proper, should be charged to the "A.C. Control and Main Connections" item. All individual grounds for structures to be included in foundation item. Grounds for equipment such as oil switches and transformers, to be included in the equipment item. (Items 261-262, 263 and 264, cost for each type of structure.)

261 *Air and Oil Switch Structures*—
- 261.1 Foundation and pits, including anchor bolts.
- 261.2 Switch structure.
- 261.3 Oil switches, bypass, disconnecting and ground switches, with all mechanical control on structure and conductor on structure only.

262 *Main Bus Structure*—
(Cost per circuit.)
- 262.1 Foundation, including anchor bolts.
- 262.2 Structures.
- 262.3 Equipment, including insulators, disconnecting and ground switches and conductors.

263 *Current and Potential Transformers*—
(Cost per transformers.)
- 263.1 Foundation, including anchor bolts.
- 263.2 Structures.
- 263.3 Equipment, including fuses, disconnecting switches, etc.

NOTE: If bushing-type current transformers, charges should come under item 261.3. Do not include conduit and wiring for metering, this is under "A.C. Control and Main Connections" item. Concrete poles are considered as structures.

264 *Fuse Structures*—
(Cost per structure.)
- 264.1 Foundations, including anchor bolts.
- 264.2 Structure.
- 264.3 Equipment, including fuses.

NOTE: This item covers three-pole fuse structures. Switch and fuse structures used with current and potential transformers should be kept under item 263.

265 *Interconnecting H.T. Wiring*—
- 265.1 Supporting, structure erected, such as end structures, etc.
- 265.2 Interconnecting H.T. wiring and insulators from line side of switch to transformer bus structure, except conductors as shown on above units.

266 *All protective guards, rails, mats, insulated stools, danger signs, fences (where used to inclose individual units), etc.*

NOTE: This item covers only guards, mats, insulated stools, etc., used in connection with high tension structures and equipment only. Guards and mats for low tension equipment are to be charged to item 288.

530 *Poles and Fixtures*—

531 *Transmission pole locations, including field survey, profile expense, etc.*

532 *Transmission poles and fixtures.*

NOTE: This item shall include the cost of all poles and structures of wood or concrete, crossarms, insulator pins, brackets, braces, pole fixtures, guys and supports, together with the cost of installation, for supporting transmission pole line conductors. Also includes pole set between two towers in a tower line, pole being used to support a disconnecting switch.

- 532.1 Digging holes for poles (not including holes for guys or guy stubs).
  - 532.11 Hand digging, including powder for blasting.
  - 532.12 Machine digging.
- 532.2 Hauling poles, crossarms and pole hardware.
- 532.3 Framing poles, including gaining, placing crossarms, painting pole tops and crossarms, and purchase price of poles and fixtures.
- 532.4 Raising poles (not including guy stubs).
  - 532.41 Hand raising.
  - 532.42 Machine raising.
  - 532.43 Completion of machine raising.
- 532.5 Guying poles, including digging anchor and stub holes, and placing guy anchors and stubs.
- 532.6 Stenciling poles.

533 *Distribution pole locations, including field survey, profile expenses, etc.*—Unincorporated.

534 *Distribution poles and fixtures*—Unincorporated.

NOTE: This item shall include the cost of poles and other structures, crossarms, insulator pins, braces, brackets and other pole fixtures, guys and supports, together with cost of installation; where distribution conductors are carried on transmission poles or towers, only the crossarms, pins, guys, etc., directly supporting such conductors shall be charged to this item.

- 534.1 Digging holes for poles (not including holes for guys or guy stubs).
  - 534.11 Hand digging, including purchase price of powder for blasting.
  - 534.12 Machine digging.
- 534.2 Hauling poles, crossarms and pole hardware.
- 534.3 Framing poles, including gaining, placing crossarms, painting pole tops and crossarms, and purchase price of poles and fixtures.
- 534.4 Raising poles (not including guy stubs).
  - 534.41 Hand raising.
  - 434.42 Machine raising.
  - 534.43 Completion of machine raising.
- 534.5 Guying poles, and placing guy anchor and stubs.
- 534.6 Stenciling poles.

535 *Distribution pole locations, including field survey, profile expense, etc.*—Incorporated town.

536 *Distribution poles and fixtures*—Incorporated town.
- 536.1 Digging holes for poles (not including holes for guys or guy stubs).
  - 536.11 Hand digging, including purchase price of powder for blasting.
  - 536.12 Machine digging.
- 536.2 Hauling poles, crossarms and pole hardware.
- 536.3 Framing poles, including gaining, placing crossarms, painting pole tops and crossarms, and purchase price of poles and fixtures.
- 536.4 Raising poles (not including guy stubs).
  - 536.41 Hand raising.
  - 536.42 Machine raising.
  - 536.43 Completion of machine raising.
- 536.5 Guying poles and placing guy anchor and stubs.
- 536.6 Stenciling poles.

NOTE: All items, including purchase price of material, include transportation charge to nearest railroad station.

All items for hauling material include unloading from railroad.

## Authorization for Expenditures

We found that all companies require an authorization for construction expenditures, which is approved by officers of the company and given a number that identifies it through all construction records. These authorizations are all known under different names. They should, however, contain a fairly complete description of the work to be done

DAILY TIME CARD— GENERAL CONSTRUCTION DEPARTMENT

DATE Jan. 3, 1930

Elect. (OCCUPATION)

LOCATION King City RATE 7.00 NAME No. 21

| WHAT WERE YOU DOING? | STRAIGHT TIME HOURS | OVERTIME HOURS | G. M. O. OR JOB NO. | ITEM NO. | AMOUNT $ |
|---|---|---|---|---|---|
| Clamps 60 KV Line | 8 | | 36080 | 265.2 | 7 00 |

No. 3 MEALS—COMPANY D. H. 36080 CAMP No. 7

No. ____ " PRIVATE " ____

No. ____ " CASH ____ NAME OF D. H. ____

O. K. J.D.Smith (FOREMAN) A. C. Johnson (SIGNATURE OR MARK (X) OF EMPLOYEE)

NOTE: TIME CARDS MUST BE FILLED OUT AND FILED EACH DAY OR NO TIME WILL BE ALLOWED.

TRANSPORTATION TIME CARD GENERAL CONSTRUCTION DEPARTMENT

DATE Jan. 8, 1930

Truck Driver (OCCUPATION)

LOCATION King City RATE 6.50 NAME No. 10

| WHAT WERE YOU DOING? | STRAIGHT TIME HOURS | OVER TIME HOURS | G. M. O. OR JOB NO. | ITEM No. | AMOUNT $ |
|---|---|---|---|---|---|
| Hauling cement | 8 | | 36080 | 273.2 | 6 50 |

No. ____ MEALS—COMPANY D. H. ____ CAMP NO. ____

No. ____ " PRIVATE " ____

No. ____ " CASH ____ NAME OF D. H. ____

O. K. J.D.Smith (FOREMAN) James Brown (SIGNATURE OR MARK (X) OF EMPLOYEE)

NOTE: TIME CARDS MUST BE FILLED OUT AND FILED EACH DAY OR NO TIME WILL BE ALLOWED.

TRANSPORTATION MILEAGE CARD

NAME James Brown CAMP No. 1665 (KNOW CO. NO.)

GENERAL CONSTRUCTION DEPARTMENT

LOCATION ____ DATE Jan. 8, 1930

| DESCRIPTION | TRIPS | MILES RUN | HOURS | JOB NO. | ITEM NO. |
|---|---|---|---|---|---|
| Hauling cement | 6 | 18 | 8 | 36080 | 273.2 |

| | TIME | SPEED O | | QUAN. | WHERE PROCURED | COUPON NO. |
|---|---|---|---|---|---|---|
| IN | 5:P.M. | 6042 | GAS-GALS. | 15 | Central Garage | 603124 |
| OUT | 8:A.M. | 6024 | OIL-QTS. | 2 | | |
| DIFF. | | 18 | GREASE-LBS. | | | |

NOTE: REPORT TIRE CHANGES ON REVERSE SIDE

*Fig. 2. Time card. The lower double card is used by truck drivers only.*

and itemized segregation of sub-accounts under each account. Opposite these items the unit costs may be shown, which are the basis of the estimated cost of that particular item.

## Application of Labor

Labor on construction work falls into various classifications as follows:

Employment of labor
Daily time cards or statements
Payrolls
Distribution of time.

*Employment of Labor—*

All labor among member companies is signed up in the field on some form of employment card, which could be standardized, both as to size, description and number of copies issued.

*Daily Time Cards or Statements—*

The recording of time in the field is handled by the various companies in several ways: through the medium of daily time cards, individual timekeeper's field checks, and foreman's individual time books. On a large job the individual daily time card is more practical, both from a payroll and segregating standpoint. The cards should be made out by the workmen, approved by the foreman, and the accounts indicated by the timekeeper.

An illustration of the daily time card is shown in Fig. 2.

*Payrolls—*

The payrolls of the various member companies are handled in several ways.

Some have individual pay sheets and time statements for the month. Other companies have a combination time sheet and payroll. The combination time sheet and payroll permits of daily postings and segregrations and saves transcribing to a payroll at the end of the month. As most of the companies use the combination individual time sheet and payroll, it will not be illustrated here. The combination time sheet and payroll which permits daily posting, segregating and balancing, staggers the load so that no peak occurs, and at the same time permits furnishing those in charge with a daily segregation. This is very important, as it permits a close check between actual costs and the estimate. This combined time sheet and payroll is shown in Fig. 3.

PAY ROLL — GENERAL CONSTRUCTION DEPARTMENT — KING CITY — Period Ending January 15

| NAME | OCCUPATION | TIME | RATE | AMOUNT | FUNCTIONS Reg. No. | FUNCTIONS AMOUNT | AMOUNT DUE | PAY ROLL CHECK NUMBER | DISTRIBUTION OR REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Branham, Lee H. | Elect. | 10-0 | 7.00 | 70 | 00 | 1 15.42 | 54 | 58 72650 | |
| | Meals | | | | | | | | |
| Harmer, Parrel T. | Labor | 10-0 | 4.00 | 40 | 00 | | 40 | 00 72653 | |
| | Drawn at home | | | | | | | | |
| Johnson, A.C. | Elect. | 10-0 | 7.00 | 70 | 00 | 1 17.50 | 52 | 50 72652 | 1.75 |
| | Meals | | | | | | | | |
| Krill, H.R. | Clerk | .5 | 1.50 | 62 | 50 | 1 17.50 | 45 | 00 72652 | |
| | Meals | | | | | | | | |
| Monohartie, T.J. | Elect. | 10-0 | 7.00 | 70 | 00 | 1 14.58 | 55 | 42 72651 | |
| | Meals | | | | | | | | |
| Rider, T.D. | Elect. | 10-0 | 7.00 | 70 | 00 | 1 15.81 | 54 | 19 72654 | |
| | Meals | | | | | | | | |
| Rohrke, H.A. | Carpenter | 2-0 | 7.00 | 14 | 00 | 1 1.75 | 10 | 25 81911 | 1.75 |
| | Meals | | | | | | | | |
| Smith, J.D. | Foreman | .5 | 7.00 | 70 | 00 | 1 17.50 | 52 | 50 72655 | |
| | Meals | | | | | | | | |
| Studwell, D.H. | App. Elect. | 10-0 | 6.00 | 60 | 00 | 1 18.75 | 41 | 25 72656 | |
| | Meals | | | | | | | | |
| Vint, Jack | Cook | .5 | 100.00 Yd. | 50 | 00 | | 50 | 00 72657 | |
| | | | | 616 | 50 | 120.00 | 491 | 67 | |

Totals Brought Forward 145 Amount 222.50 Daily Totals Carried Forward 62 Amount 134.00 Previous Totals Amount

I.C.Brown — H.R.Krill — Geo.Smith — J.W.Doe — J.D.Kelly — J.D.Smith

FOR USE OF GENERAL OFFICE AUDITING DEPT.

| | | | |
|---|---|---|---|
| 1. Total Brought Forward | 120.00 | 1. | |
| 2. Total This Carried Forward | | 2. | |
| 3. This Column | | 3. | |
| 4. Previous Total | | 4. | |
| 5. Amounts Reversed | | 5. | |
| 6. Error | | 6. | |
| a. Employees' Age Tax | 2.00 | a. | |
| b. | | b. | |
| TOTAL DEDUCTIONS | 122.50 | c. | |

NOTE: Use the following code letters with the date for employee's discharge or resignation. A- laid off for lack of work. B- resigned, no reason given. C- resigned for reason. D- discharged for cause. E- miscellaneous, "such as death, etc." When using codes "C" "D" and "E", show employee's name and reason or cause for resignation or discharge on reverse sheet of payroll.

GENERAL CONSTRUCTION DEPARTMENT

*Fig. 3. Combined time sheet and payroll.*

*Distribution of Time—*

The distribution of time is handled by the member companies in various ways. As most of the companies have adopted the individual time sheet, the distribution naturally takes place at the end of the payroll period. This does not permit any daily or progressive analysis of labor costs. The system used by another member company permits of a daily total, progressively kept against each item of work, which is readily tied into physical units. This is fully explained in another section of the report.

| Requisition Number | Item No. or Mark | Quantity | Description | Catalog or Drawing Reference | Remarks | Purchasing Order-No. | Material Was-Rec. | Item No. |
|---|---|---|---|---|---|---|---|---|
| Memo Order | | | CONTRUCTION AS OF - 1929 | AUTHORIZATION G.L. O-36080 | | | | |
| 120601 | 1 | 1 | Structure, Switch & Fuse, 60 KV., 3 Pole Complete with P.E.M.Co. 74 KV., 200 Amp., Type S, Disconnecting Switch. | P.E.M.Co. Dwg.#A-2200 | M.P.R. #4361 | 4R 7227 | 12/18/29 | 264.2 |
| 120602 | 2 | 1 | Structure, Disconnecting Switch, 25'-6" High Above Foundation, without grounding Switch | Dwg. #25521 G-3 | M.P.R. #4378 | 4R 7718 | 12/18/29 | 261.2 |
| " | 3 | 1 | Pole, Latticed Steel, Type C, Pole #1, L-38'-6" F-6'-6" | Dwg. #38346 | M.P.R. #4378 | 4R 7718 | 12/18/29 | 265.1 |
| " | 4 | 1 | Pole, Latticed, Steel, Type C, Pole #3, L-25'-6" F-6'-6" | Dwg.#38346 | M.P.R.#4378 | " | " | " |
| " | 5 | 1 | Pole, Latticed, Steel,Type C, Pole #5, L-31'-6" F-6'-6" | Dwg.#38346 | M.P.R. #4378 | " | " | " |
| " | 6 | 1 | Pole, Latticed, Steel, Type A, Pole #6, L-38'-6" F-6'-6" | Dwg.#38346 | M.P.R. #4378 | " | " | " |
| 120603 | 7 | 120 | Insulator, Suspension, Ball & Socket Type | Code #17928 | | 4R 12013 | 1/25/30 | 265.2 |
| 120618 | 8 | 14 | Clamp, Strain, #2/0 Cable, Socket Type Insulator | Locke Co. Cat.#3305-G-2 | For Item (7) | 4R 12014 | 1/25/30 | |
| 120603 | 9 | 20 | Hook, Suspension, Socket Type | O.B.Co. Cat.#13394 | For Item (7) | 4R 12013 | 1/25/30 | |
| " | 10 | 5 | Insulator, Pin Type, 60 KV., 4 Part | W.E.& M.Co.Style #4166 | | 4R 12013 | 1/25/30 | " |
| " | 11 | 5 | Pin, Insulator, with Malleable Iron Flange, Galv. 5" B.D. & 13" Pin | Dwg. #06769 G-7 | | 4R 12013 | 1/25/30 | " |
| 120604 | 12 | 20 | Bolt, Mach., 5/8"x14", with C.P.Hex. Nut, Galv. | | For Item (11) | 4R 12016 | 1/25/30 | " |
| 120605 | 13 | 800'-0" | Cable, #2/0 Bare, Stranded, Hard Drawn Copper | | | 4R 12018 | 1/27/30 | " |
| 120606 | 14 | 7 | Lighting Standard, Tubular Pole, 200 Watts, Complete with Ivanhoe No.R.2.L.-100 Reflector and No.936 Glass Cover | Dwg.#08855 G-1 | | 4R 12021 | 1/27/30 | 19 |
| 120607 | 15 | 640'-0" | Fence, Property, 6'-0", Std. Chain Link, Fabric on Steel Posts with one 12'-0" Double Swing Gate and One 4'-0" SingleSwing Gate, Omit Barbed Wire Top | Dwg.#08924 | Inclosure 150'-0"x170'-0" | 4R 13384 | 2/20/30 | " |
| 120608 | 16 | 2 | Foundation, Concrete for 73 KV Switch & Fuse Structure | P.E.M.Co.Dwg.#D-3792 | For Items(1) (33) | 4R 13205 | Concrete | Mix. |
| 120618 | 17 | 6 | Clamp, Strain, #2 Cable, Socket Type Insulator | Locke Co.Cat.#3304-G-2 | | 4R 13223 | Cement | 264.1 |
| 120610 | 18 | 3 | Clamp, Parallel, Type WV, #2 Aluminum to #2/0 Copper Cable | P.E.M.Co. Cat.#12422 | | 4R 12014 | 1/25/30 | 265.2 |
| | | | | | | 4R 12017 | 2/25/30 | " |
| 120603 | 19 | 425'-0" | Wire, Guy, 1/8" Mi.Str. | | | 4R 12013 | 1/25/30 | 265.1 |
| " | 20 | 2 | Platform, Insulated, Ground Type, L-61'-0", S-4'-0" | Dwg.#08764 | | 4R 12013 | 2/7/30 | 266. |
| " | 21 | 3 | Platform, Insulator, 2'-6"x2'-8 | Dwg.#08246 | | " | 1/25/30 | " |
| " | 22 | 5 | Rod, Anchor, 3/4" Dia., 9'-0" Long,Drip Forged, Oval Eye, with Square Nut, Hot Galv. | Hubbard #28 Cat. Stock No.7429 | For Item (30) | " | 1/25/30 | 265.1 |
| " | 23 | 20 | Thimble, Guy, 1/8", M.C.H. Steel, Hot Galv. | Dwg.#06539 | | " | 1/25/30 | " |
| " | 24 | 20 | Clamp, Guy, 4". 2 Bolts, C.H.Steel, Hot Galv. | Dwg.#06537 | | " | 1/25/30 | " |
| 120604 | 26 | 24 | Bolts, Mach., 5/8" x6", with C.P.Hex. Nut and Washer, Galv. | | For Items(21)(31) | 4R 12016 | 1/25/30 | 266. |

BILL OF MATERIAL - #011285 To Accompany Dwg. #44524 - General Arrangement Outdoors King City Substation G.L.O.36080

*Fig. 4. Standard bill of material.*

## Material Used

Material for construction projects falls under the following classifications with most of the member companies:

Bill of material
Construction requisition
Purchase order
Report of material received
Distribution of material
Emergency and local purchases.

### *Bill of Material—*

We feel that, in all construction work of any magnitude, a bill of material should be issued. This should provide space, in addition to the material itself, for the purchase order number, date received, and standard item to which the material is to be charged, which item is approved by either the accounting or engineering departments. This procedure furnishes a comprehensive analysis of ordering, receipt, and disposal of material.

GENERAL CONSTRUCTION DEPARTMENT
MEMORANDUM ONLY

DATE 1/8 1930

OFFICE: PLEASE ORDER THE FOLLOWING MATERIAL:
SHIP TO Pacific Coast Gas & Electric Co., % General Construction Dept.
ADDRESS King City, Monterey County, California.
VIA Freight APPROVED J.D.Smith FOREMAN

| QUANTITY WANTED | DESCRIPTION (DESIGNATE ARTICLE PLAINLY AND FULLY, GIVE CATALOG AND PAGE NUMBER, OR DRAWING NUMBER WHEN NECESSARY) | G. M. ITEM |
|---|---|---|
| 6 | Clamps, strain, #2 cable, socket type insulator, Locke Co. | |
| | Cat. #3304 G-2 | |
| 14 | Clamps, strain #2/0 cable, socket type insulator, Locke Co. | |
| | Cat. #3305 G-2 | |
| | | |
| | Delivery at site by Jan. 31, 1930. | |
| | | |
| | | |

FOR G. M. NO. 36080 FOR USE IN Item 265.2 B/M 011285
REMARKS:
MEMO 120618
ORDER NO 4R 12014

*Fig. 5. Construction requisition.*

We are showing a standard bill of material as selected from one of the member companies as Fig. 4.

### *Construction Requisition—*

The construction requisition is used by many of the member companies and is usually a memorandum order issued by the construction forces to the general or head office covering material requirements taken either from the plans or from the bill of material. The construction requisition, which should be a numbered form and signed by the foreman, is either placed on other construction jobs or else covered by a purchase order. It should be followed up by the field in order that it cannot be misplaced or lost, and should show the authorization number, bill of material number, and standard item number on which the material will be charged and used.

An illustration of a construction requisition is shown as Fig. 5.

### *Purchase Order—*

The purchase order, which is more or less uniform with member companies, is placed through the stores department or on outside vendors. It should contain all of the facts,

EXHIBIT "E"

REPORT OF MATERIAL RECEIVED No. 610

King City Cal., 6/5 1930

From Listenwaltzr & South Via Parcel Post Truck No. -
Received at King City Order No. 682430 Req.No. 3/128 Driver -

| Pkge | Weight | Quantity | Description of Material | Condition |
|---|---|---|---|---|
| 1 | 10# | 6 | Burndy Lugs for 4/0 Cable Cat.#AU28 | O.K. |
| | | | See Inv. #89113 | |

Charge to 36080-265.2 Received By T. Jones

*Fig. 6. Report of material received.*

as shown on the construction requisition, including the item to be charged, bill of material number, and construction requisition number. The copy of this order, when forwarded to the field, serves as notification that the construction requisition has been handled.

*Report of Material Received—*

Although there are various methods in which member companies make reports of material received, two methods predominate. One is to have a material receival report sent in, the other is to forward a copy of the purchase order to the field recording the receipt of material.

An illustration of a receival report as used by one of the member companies is shown in Fig. 6.

*Distribution of Material—*

Care should be exercised in the distribution of material to see that it reaches the item for which it was ordered. A very simple method to procure this result is to have the material tagged on its arrival at the job, this tag to show the order number, the bill of material number on which it was ordered, the item purchased for, and the date received. When material is withdrawn on a foreman's order, the item thereon should be checked with the item for which the material was ordered (which shows on the material tag) and if a variance is noted, a transfer requisition should be issued. These three forms are shown in Fig. 7.

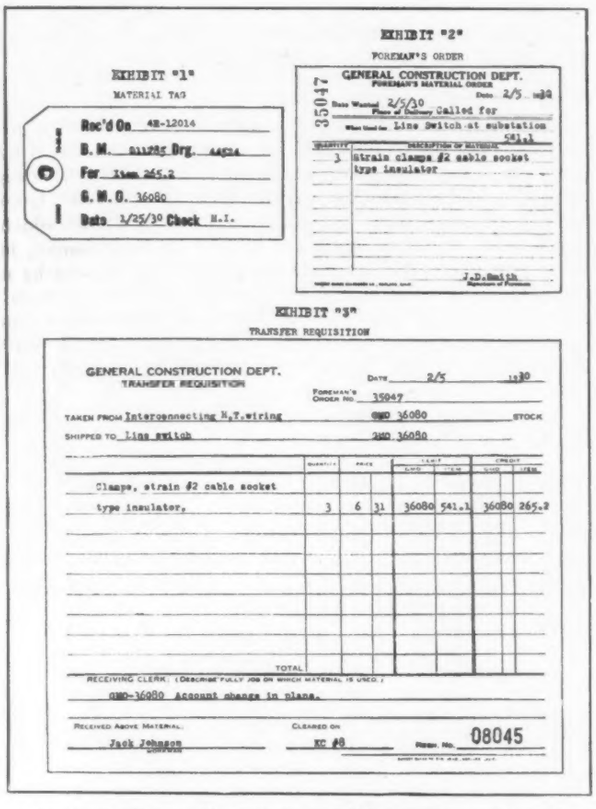
EXHIBIT "1"
MATERIAL TAG
Rec'd On 4B-12014
B. M. 811785 Drg. 44514
For Item 265.2
G. M. O. 36080
Date 1/25/30 Check H.I.
EXHIBIT "2"
FOREMAN'S ORDER
GENERAL CONSTRUCTION DEPT.
FOREMAN'S MATERIAL ORDER
35047
Date 2/5 1930
Date Wanted 2/5/30 Called for
Line Switch at substation
Strain clamps #2 cable socket type insulator
J.D.Smith
EXHIBIT "3"
TRANSFER REQUISITION
GENERAL CONSTRUCTION DEPT.
TRANSFER REQUISITION
DATE 2/5 1930
FOREMAN'S ORDER NO. 35047
TAKEN FROM Interconnecting H.T.wiring GMO 36080 STOCK
SHIPPED TO Line switch GMO 36080
Clamps, strain #2 cable socket type insulator, 3 6 31 36080 541.1 36080 265.2
TOTAL
RECEIVING CLERK. (DESCRIBE FULLY JOB ON WHICH MATERIAL IS USED.)
GMO-36080 Account change in plans.
RECEIVED ABOVE MATERIAL. Jack Johnson
CLEARED ON KC #8
REQUISITION NO. 08045

*Fig. 7. Exhibit 1. Material tag. Exhibit 2. Foreman's order. Exhibit 3. Transfer requisition.*

*Emergency and Local Purchases—*

Purchases of this nature are constantly occurring on any major job, as it is impossible to anticipate all of your material requirements through the medium of the bill of material. It is suggested that member companies equip themselves with forms on which local or small purchases may be procured directly by the field, this order to have sufficient copies for distribution to the vendor, field files, and head office. This

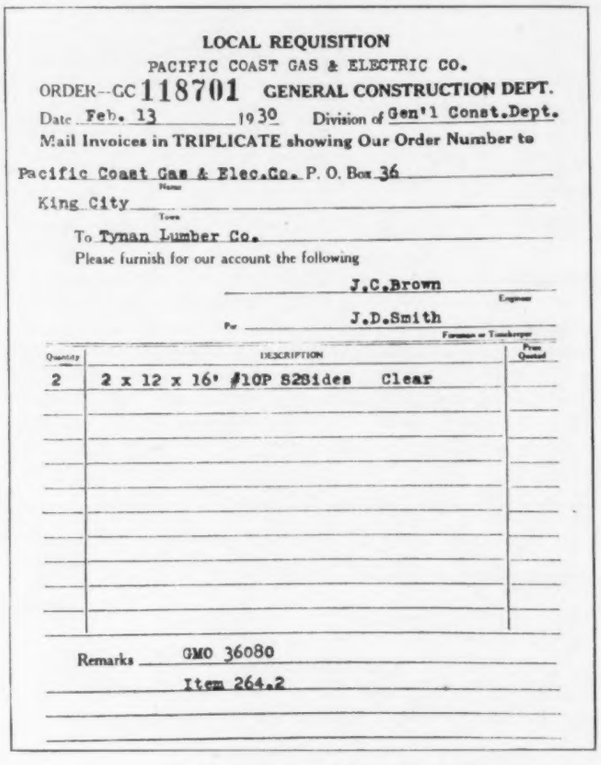
LOCAL REQUISITION
PACIFIC COAST GAS & ELECTRIC CO.
ORDER--GC 118701 GENERAL CONSTRUCTION DEPT.
Date Feb. 13 1930 Division of Gen'l Const.Dept.
Mail Invoices in TRIPLICATE showing Our Order Number to
Pacific Coast Gas & Elec.Co. P. O. Box 36
King City
To Tynan Lumber Co.
Please furnish for our account the following
J.C.Brown Engineer
Per J.D.Smith Foreman or Timekeeper
Quantity DESCRIPTION Price Quoted
2 2 x 12 x 16' #10P S2Sides Clear
Remarks GMO 36080
Item 264.2

*Fig. 8. Local requisition blank.*

allows the field some latitude and permits the handling of emergency and small material requirements with a minimum of delay. These orders should show the authorization number and item on which the material is to be used and directions for billing.

An illustration of an emergency or local purchase form is shown in Fig. 8.

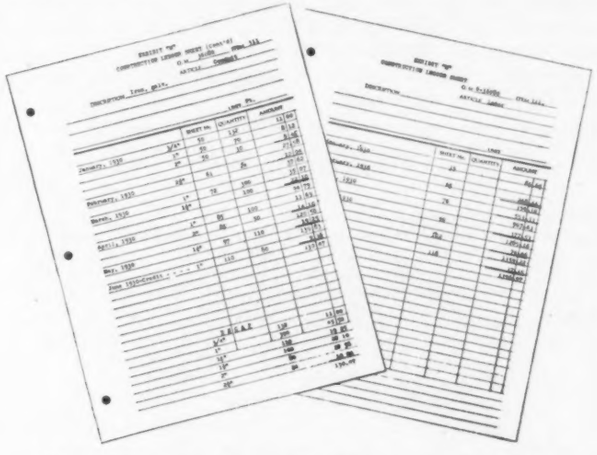

*Fig. 9. Two samples of pages from construction ledger.*

## Tabulation of Costs

The preparation of construction costs falls into the following captions:

The Construction Ledger
Statement of Expenditures
Analysis of Costs.

*Construction Ledger—*

The methods adopted by member companies for accumulating their construction costs vary with each company. There is no uniformity in handling the preparation of costs on construction ledgers; in fact some of the companies make no attempt to render costs at all, while others issue complete detailed costs on every project. The company which goes into this latter phase of its construction activities has adopted a ledger which accumulates costs progressively and alphabetically by items and, on the completion of the job, these costs are available for typing direct from the construction ledgers. Two samples from this ledger are shown as Fig. 9.

MONTHLY STATEMENT OF EXPENDITURES
GENERAL CONSTRUCTION DEPARTMENT

G.W.O. 36080 — As of Jan. 31,1930.

The work embraced by this G.W.is - Rebuilding King City Substation

Signed J. D. Smith

| Item | Description | Sub Item Exp.to Date | Main Item Exp.to Date | Est. Costs |
|---|---|---|---|---|
| 19. | Improvements to Property | 1447.49 | 1447.49 | 5600.00 |
| 21. | Sub. Bldg. Complete | 461.76 | 461.76 | No Estimate |
| 261.1 | Air Sw. Structure Foundations | 12.22 | | |
| 261.2 | do | 2.33 | | |
| 261.3 | Air Sw. All Mech. Control | 15.82 | | |
| 264.1 | Fuse Structure Foundations | 110.23 | | |
| 264.2 | do | 987.40 | | |
| 264.3 | Fuse Structure Equip. incl.Fuses | 990.28 | | |
| 265.1 | H. T. Structures | 478.67 | | |
| 265.2 | H. T. Wiring | 623.29 | | |
| 266. | H. T. Guards | 70.10 | | |
| 260. | | | 1208.14 | 4500.00 |
| 271. | Trans. Foundation | 182.96 | | |
| 272. | Trans. Dried tested, etc. | 2491.24 | | |
| 273.2 | Trans. Bus Structure | 1930.11 | | |
| 273.3 | Trans. Bus Equipment | 2060.16 | | |
| 278. | #2 Trans. Bk. Foundation | 60.28 | | |
| 279.2 | #2 Trans. Bk. Structure | 161.37 | | |
| 279.3 | #2 Trans. Bk. Equipment | 221.20 | | |
| 270. | | | 7116.12 | 5500.00 |
| 281.1 | Outdoor Sw. Str. inc. Foundation | 666.68 | | |
| 281.2 | Outdoor Sw. Equipment | 8669.44 | | |
| 288. | L. T. Guards | 68.51 | | No Estimate |
| 280. | | | 9146.84 | 12500.00 |
| 301. | AC & DC Control & Switchboard | 292.24 | 292.24 | No Estimate |
| 311. | AC Control & Main Connections | 616.64 | | |
| 312. | General Ground System | 265.23 | | No Estimate |
| 310. | | | 882.87 | 1200.00 |
| 361. | Induction Reg. Foundation | 21.73 | | |
| 363. | Aux. & Disconnect Sw.Installed | 3.00 | | |
| 360. | | | 24.73 | 1800.00 |
| 382. | Storage Battery | 76.59 | | |
| 383. | Charging Sets Incl. found | 48.14 | | |
| 380. | | | 124.73 | No Estimate |
| 392. | Sta. Light & Power Trans. | 54.33 | | |
| 393. | Wiring (Incl.Instrv.Trans) | 42.33 | | |
| 390. | | | 96.66 | 400.00 |
| 534. | Distr. Poles & Fixtures | No Expenditure | | No Estimate |
| 542. | Distr. Pole Line Condr. & Sw. | No Expenditure | | 200.00 |
| 611. | Permanent Tools | 21.52 | 21.52 | No Estimate |
| 630. | Replacement Expense | No Expenditure | | 150.00 |
| 640. | Maintenance Expense | No Expenditure | | 150.00 |
| 650. | Operating Expense | No Expenditure | | 100.00 |
| 1001.1 | Field Superintendence | 70.81 | | |
| 1001.2 | General | 41.73 | | |
| 1002. | Field and Office Engineering | 2226.67 | | |
| 1003. | Field and Office Accounting | 127.60 | | |
| 1000. | | | 2466.81 | 2000.00 |
| 1011. | Camp Erection | 21.76 | | |
| 1013. | Tools and Equipment | 361.19 | | |
| 1014. | Stores Expenses | 298.56 | | |
| 1018. | Temporary Telephone | 25.07 | | |
| 1010. | | | 708.78 | 750.00 |
| 1021. | General Engineering | 114.09 | | |
| 1022. | Administrative Expense | 223.38 | | |
| 1023. | Interest During Construction | 372.44 | | |
| 1020. | | | 709.89 | 1650.00 |
| 1032. | CREDIT | 125.00 | 125.00 | No Estimate |
| Pending | Investigation Suspense | 169.85 | 169.85 | |
| | TOTAL | | 27037.03 | 38900.00 |

*Fig. 10. Monthly statement of expenditures.*

*Statement of Expenditures—*

A monthly statement of expenditures is issued by most of the member companies . An illustration of a statement from the company which issues costs on all projects is shown as Fig. 10.

*Analysis of Costs—*

Analysis of costs is most important and should be made by a cost engineer or one in the engineering department, who is competent to check the costs as turned in by the field forces, with the plans, estimates, and bills of material. This analysis should terminate in a final cost report, so compiled that it can be used by the engineering department for unit costs and future estimates, by the valuation engineer for valuation work, by the auditing department for capitalization and plant write-offs, etc.

A portion of a completed cost report follows:

EXTRACT OF UNIT COST REPORT

| Item | Description | | Material Subtotal | Total Expenditure |
|---|---|---|---|---|
| 260. | High Tension from Line Side of Switches to Transformer Structure | | | |
| 261. | Five 110-kv. Oil Switches Erected Complete. | | | |
| 261.1 | Foundations in Place, for Towers and Oil Switches. | | | |
| | Labor | | $1,354.71 | |
| | Cost of Transportation | | | |
| | Freight | $ 3.23 | | |
| | Auto hire and hauling | 158.59 | | |
| | | | 161.82 | |
| | Stores expense | | 12.53 | |
| | Cost of Material and Supplies | | | |
| | 128 Bolts, anchor, galv. | $ 50.20 | | |
| | 636 Sk. Cement | 548.17 | | |
| | 96 Yd. Rock | 128.76 | | |
| | 48 Yd. Sand | 60.00 | | |
| | 7,740 Lb. Steel, reinf. | 213.17 | | |
| | | | 1,000.30 | |
| | Total Expenditure Item 261.1 | | | $2,529.36 |

UNIT COST

Cost of Foundations for Oil Switches and Towers:

| Description | Total | Per Switch or Tower (5 switches & towers) | Per Cu.Yd. Concrete (109 Cu. Yd.) | % |
|---|---|---|---|---|
| Labor | $1,354.71 | $270.94 | $12.43 | 53.56 |
| Cement | 548.17 | 109.63 | 5.03 | 21.67 |
| Rock | 128.76 | 25.75 | 1.18 | 5.09 |
| Sand | 60.00 | 12.00 | .55 | 2.37 |
| Reinforcing | 209.74 | 41.95 | 1.92 | 8.29 |
| Other | 227.98 | 45.60 | 2.09 | 9.02 |
| Total | $2,529.36 | $505.87 | $23.20 | 100% |

| Item | Description | | Material Subtotal | Total Expenditure |
|---|---|---|---|---|
| 261.2 | Structures Erected for Equipment | | | |
| | Cost of Labor | | | |
| | Labor | $975.97 | | |
| | Personal expenses | 24.52 | | |
| | | | $1,000.49 | |
| | Cost of Transportation | | | |
| | Freight | $94.93 | | |
| | Auto hire and hauling | 83.10 | | |
| | | | 178.03 | |
| | Stores expenses | | 28.23 | |
| | Cost of Material and Supplies | | | |
| 5 | Assemblies, right hand, K-425 | $ 10.65 | | |
| 5 | Assemblies, left hand, K-426 | 10.65 | | |
| 222 | Bolts, assorted | 14.02 | | |
| 40 | Bolts, anchor, 1¾"x1½"x4' | 30.68 | | |
| 2,003 | Bolts, galv., assorted | 120.30 | | |
| 40 | Flanges, galv. 2½"x7" | 34.00 | | |
| 496 2/12 Ft. | Iron, angle, assorted | 102.00 | | |
| 40 | Nuts, galv. hex. 1⅛" | 6.66 | | |
| 12 | Plates, K-434 | 6.94 | | |
| 8 | Plates, galv. ½"x8⅞"x11" | 10.00 | | |
| 913½ Lb. | Steel, soft | 31.99 | | |
| | Steel, structural, as per Dwgs. | 675.00 | | |
| 5 | Towers, snow, with bolts | 1,076.56 | | |
| 5 Pcs. | Tower angles, K-160 | 122.75 | | |
| | | | 2,252.20 | |
| | Total Expenditure Item 261.2 | | | $3,458.95 |

Cost of Towers Erected:

| Description | Total | Per Tower (5 towers) | Per Lb. Steel (21,820 Lb.) | % |
|---|---|---|---|---|
| Labor | $ 975.97 | $195.19 | .045 | 28.23 |
| Towers | 1,199.21 | 239.85 | .054 | 34.65 |
| Other | 1,283.77 | 256.75 | .059 | 37.12 |
| Total | $3,458.95 | $691.79 | .158 | 100% |

| Item | Description | | Material Subtotal | Total Expenditure |
|---|---|---|---|---|
| 261.3 | Oil Switches, Bypass and Disc. Switches with Control Installed Complete, Incl. Copper to Oil Switch Terminals: | | | |
| | Cost of Labor | | | |
| | Labor | $4,143.78 | | |
| | Personal expenses | 8.00 | | |
| | | | $4,151.78 | |
| | Cost of Transportation | | | |
| | Freight | $ 122.35 | | |
| | Freight on 5 breakers | 3,898.88 | | |
| | Auto hire and hauling | 251.98 | | |
| | | | 4,273.21 | |
| | Stores expense | | 849.70 | |
| | Cost of Material and Supplies | | | |
| | 5 Breakers, outdoor type, oil circuit, 115,000-volt, type F.K.O.-36-33C, triple pole, single throw, 400-amp., complete with bushing type current transformers | $56,100.43 | | |
| | 40 Insulators, No. 03750 | 8.87 | | |
| | 294 Insulators, No. 26333, Post type | 7,600.70 | | |
| | 240 Insulators, O.B. No. 36166, susp. | 622.00 | | |
| | For purpose of exhibit balance of detail of material not shown amounting to | 3,467.21 | | |
| | | | 67,799.21 | |
| | Total Expenditure Item 261.3 | | | $77,073.90 |
| | Total Expenditure Item 261 | | | 83,062.21 |

UNIT COST

FIVE 110-KV. OIL SWITCHES ERECTED COMPLETE

| DESCRIPTION | Labor | Material | Total | Per Switch Tower (5 switches & towers) | % Labor |
|---|---|---|---|---|---|
| Foundations | $1,354.71 | $ 1,174.65 | $ 2,529.36 | $ 505.87 | 53.55 |
| Structures | 975.07 | 2,482.98 | 3,458.95 | 691.79 | 28.22 |
| Oil Switches, Bypass & Disc. Switches | 4,143.78 | 72,930.12 | 77,073.90 | 15,414.78 | 5.37 |
| Subtotal | $6,474.46 | $76,587.75 | $83,062.21 | $16,612.44 | 7.79 |
| Indirect | | | 1,092.65 | 218.53 | |
| Overhead | | | 1,923.44 | 384.68 | |
| Head Office Overhead Exp. | | | 7,549.10 | 1,509.82 | |
| Total | | | $93,627.40 | $18,725.47 | |

The procedure outlined and suggested above is principally adopted for major jobs, although it may be used on any size or type of work successfully. Its use, however, depends upon control from the head office, both from a labor and material standpoint, as that is where all items are assigned and items for material lists applied. This tends to keep all jobs uniform in the application of labor and material charges.

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## *Payroll System of the General Construction Department — Pacific Gas and Electric Company**

*The purpose of the following outline is to present briefly a description of the payroll and segregation system which has been designed to meet the requirements of the general construction department. Since it has been found advisable to do the accounting for the larger construction jobs in the field, thereby permitting a closer supervision of expenditures, it has been the constant aim to simplify the accounting routine so that costs could be reduced to a basis comparable with those which would be incurred in the centralized organization.*

A RECENT revision of the routine involved in the segregation of labor has prompted the preparation of this paper. The principles underlying the revised system are the same as those previously observed, yet the simple application of a mechanical accounting idea has produced results far exceeding original anticipations. It involves the use of a simple adding machine, to which have been added certain features needed to accomplish the desired results. Since such equipment is essential on the average job, the investment in the accounting feature of the application is negligible.

This particular payroll system has enabled one clerk to take care of the payroll and labor segregation for over 550 men with much less effort than formerly required for 300. It has entirely eliminated the use of bulky and cumbersome "spread sheets" and their laborious reconciliation with the payroll at the end of each period and has enabled the preparation of a detailed record of the segregation, that requires a minimum of filing space. The routine, as will be observed from the description, is very simple and can therefore be taught to any clerk familiar with the fundamentals of timekeeping.

The intelligent direction of the construction program and the efficient functioning of each of its numerous elements is dependent upon information usually assembled with and obtainable from accounting records. The construction superintendent must frequently consult these records and obtain from them, or from the bureau maintaining them, amplification of details required for a better understanding of the work as it progresses. The need for such information varies substantially during the progress of the work, but its usefulness is always dependent upon its timeliness. An analysis of cost, or a progress report on some specific operation, may be of vital importance at one time, but may have less significance at another. It is not possible for the man in general charge of a construction job to anticipate in advance just what information he may need or the purpose for which he may require it. The circumstances that call for data may develop quite suddenly, unexpected emergencies being a common experience in construction work. Under such conditions he finds the assistance of the accounting personnel and its records of extreme timeliness and value.

The method described herewith furnishes daily and progressive labor costs broken down into items and tied in with physical units, which can readily be compared with the estimate. We feel that one of the essential tasks before an accounting organization is to keep constantly before those in charge, current and progressive costs.

### BRIEF OUTLINE OF PROCEDURE IN EMPLOYMENT OF MEN

Application for employment is usually made to the foremen on the jobs. When a man is hired, a card such as that illustrated in Fig. 1 is filled out by the foreman and given to him, and he in turn presents it to the timekeeper.

602423 10-29-2M

PACIFIC GAS AND ELECTRIC COMPANY
GENERAL CONSTRUCTION DEPARTMENT

Dec- 15 1930

MR. Arthur Higgins
CAMP Station A

THIS IS TO ADVISE THAT THE

BEARER George Shaw NO. 389

SIGNED UP TO BEGIN WORK FOR YOU AT ONCE AS Electrician

AT $ 7.50 PER DAY / MONTH

SIGNED J.A. Armstrong
TITLE Foreman

*Fig. 1. Card for timekeeper made out at time of employment.*

2206 3-29-4M

PACIFIC GAS AND ELECTRIC COMPANY

Town San Francisco
Date Dec- 15 1930

Dr. A. T. Vaughn
Address 950 Market
Office Hours 9.00 - 4.00
Please examine the bearer George Shaw
applicant for employment as Electrician (KIND OF WORK)
in the Construction Dept. at Station A.

J A Armstrong
MANAGER, SUP'T, FOREMAN

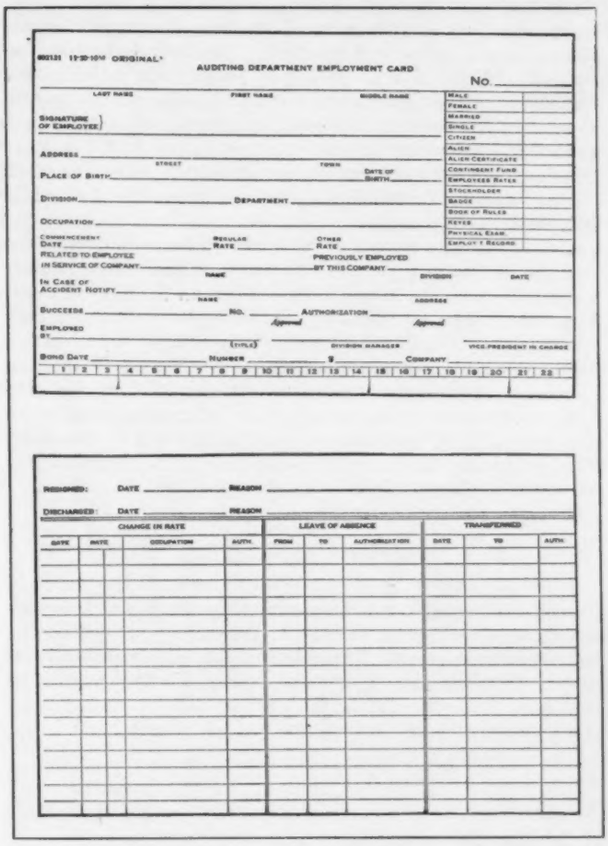
(Reverse side to be filled out by Physician)

*Fig. 2. Medical inspection card made out at time of employment.*

Upon its presentation, he is given a card such as that illustrated in Fig. 2, the purpose of which is self-explanatory.

If the medical examination is passed, the employment card illustrated in Fig. 3 is filled out, in triplicate, one copy being retained in the field and the other two forwarded to

* Part 2 of report of subcommittee on construction accounting, classification of accounts committee, Accounting Section. E. E. Dodge, chairman.



AUDITING DEPARTMENT EMPLOYMENT CARD

No. _____

LAST NAME — FIRST NAME — MIDDLE NAME

SIGNATURE OF EMPLOYEE

ADDRESS — STREET — TOWN

PLACE OF BIRTH — DATE OF BIRTH

DIVISION — DEPARTMENT

OCCUPATION

COMMENCEMENT DATE — REGULAR RATE — OTHER RATE

RELATED TO EMPLOYEE IN SERVICE OF COMPANY — NAME — PREVIOUSLY EMPLOYED BY THIS COMPANY — DIVISION — DATE

IN CASE OF ACCIDENT NOTIFY — NAME — ADDRESS

SUCCEEDS — NO. — AUTHORIZATION — Approved — Approved

EMPLOYED BY — (TITLE) — DIVISION MANAGER — VICE-PRESIDENT IN CHARGE

BOND DATE — NUMBER — $ — COMPANY

MALE, FEMALE, MARRIED, SINGLE, CITIZEN, ALIEN, ALIEN CERTIFICATE, CONTINGENT FUND, EMPLOYEES RELIEF, STOCKHOLDER, BADGE, BOOK OF RULES, KEYES, PHYSICAL EXAM, EMPLOY'T RECORD

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

RESIGNED: DATE _____ REASON _____

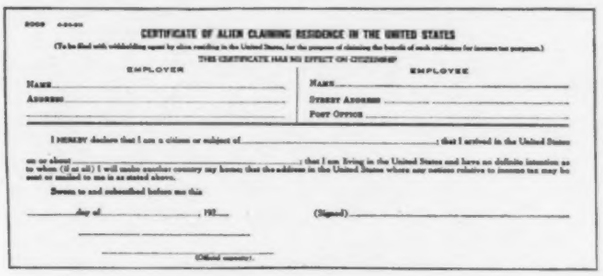
DISCHARGED: DATE _____ REASON _____

| CHANGE IN RATE | | | | LEAVE OF ABSENCE | | | TRANSFERRED | | |
|---|---|---|---|---|---|---|---|---|---|
| DATE | RATE | OCCUPATION | AUTH. | FROM | TO | AUTHORIZATION | DATE | TO | AUTH. |
| | | | | | | | | | |

*Fig. 3. Front and back of auditing department employment card.*

the central accounting office. The reverse side of this card contains pertinent data necessary to complete the record of his employment.

In the event the applicant is not a citizen of the United States, he is required to fill out the certificate illustrated



CERTIFICATE OF ALIEN CLAIMING RESIDENCE IN THE UNITED STATES

(To be filed with withholding agent by alien residing in the United States, for the purpose of claiming the benefits of such residence for income tax purposes.)

THIS CERTIFICATE HAS NO EFFECT ON CITIZENSHIP

EMPLOYER — EMPLOYEE

NAME — NAME

ADDRESS — STREET ADDRESS

POST OFFICE

I HEREBY declare that I am a citizen or subject of _____; that I arrived in the United States on or about _____; that I am living in the United States and have no definite intention as to whom (if at all) I will make another country my home; that the address in the United States where any notices relative to income tax may be sent or mailed to me is as stated above.

Sworn to and subscribed before me this

_____ day of _____, 19__. (Signed) _____

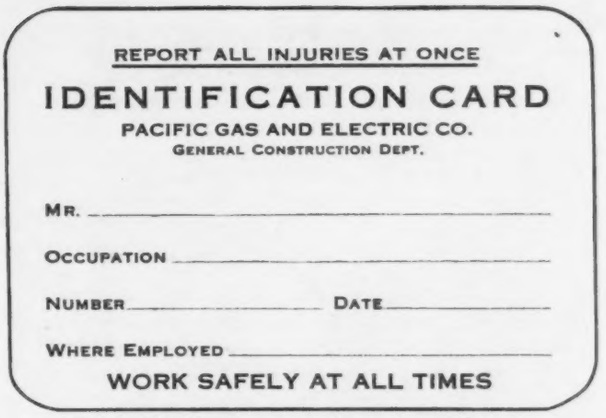
(Official capacity.)

*Fig. 4. Citizenship certificate for income tax purposes.*

in Fig. 4. This document is for income tax purposes only and has no bearing on the citizenship of the individual.

The identification card illustrated in Fig. 5 is filled out and given to each man with instructions to carry it at all times while on the job, as it must be presented upon request.

An arbitrary number corresponding to that of a brass check is given to each man. These are given out to the individual men as they report to work each day. Five minutes after the official starting time, all numbers appearing on the unclaimed checks are reported to the timekeeper, who makes out a list of the individuals corresponding to the numbers and gives it to the foreman. The latter checks it to make certain that the men listed thereon are actually absent and did not fail to pick up their check on reporting to work. When the list is approved and returned



REPORT ALL INJURIES AT ONCE

IDENTIFICATION CARD

PACIFIC GAS AND ELECTRIC CO.

GENERAL CONSTRUCTION DEPT.

MR. _____

OCCUPATION _____

NUMBER _____ DATE _____

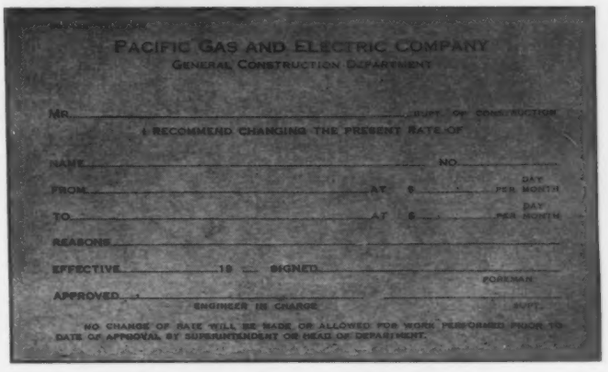
WHERE EMPLOYED _____

WORK SAFELY AT ALL TIMES

*Fig. 5. Identification card to be carried at all times.*

to the timekeeper, "No Work," time cards are prepared for the absentees and no time is allowed for that day.

Any changes made in the rate of pay subsequent to that established at the time of employment is noted on the form illustrated in Fig. 6.



PACIFIC GAS AND ELECTRIC COMPANY

GENERAL CONSTRUCTION DEPARTMENT

MR. _____ SUPT. OF CONSTRUCTION

I RECOMMEND CHANGING THE PRESENT RATE OF

NAME _____ NO. _____

FROM _____ AT $ _____ PER DAY PER MONTH

TO _____ AT $ _____ PER DAY PER MONTH

REASONS _____

EFFECTIVE _____ 19__ SIGNED _____ FOREMAN

APPROVED _____ ENGINEER IN CHARGE _____ SUPT.

NO CHANGE OF RATE WILL BE MADE OR ALLOWED FOR WORK PERFORMED PRIOR TO DATE OF APPROVAL BY SUPERINTENDENT OR HEAD OF DEPARTMENT.

*Fig. 6. Card on which change in payment is recorded.*

### Time Recording

A time card such as that illustrated in Fig. 7 is prepared and turned in daily by each man; foremen and miscellaneous individuals on monthly rates of pay being excepted. They, however, are required to prepare at least one for each pay period, this rule being somewhat dependent upon the distribution to be made of their labor. All data, with the exception of the distribution, must be filled in by each man.

The first time cards turned in by the newly employed are identified as such by the timekeeper. The same applies to the last one following resignation or discharge, so that the payroll records may be adjusted accordingly.

On receipt of the time cards each morning in the timekeeper's office, they are sorted alphabetically, and the time shown thereon posted to the payroll. The procedure observed on this operation is described in detail under the heading of "payroll."

After the time has been posted, the time slips are sorted by occupations and given to the foremen for verification and signature. When they are returned to the timekeeper's office, the G.M.O., job or item numbers are entered. Where the time is split between two or more items, the extension is made of the amounts to be allocated to each one. This is done to assist in the subsequent preparation of units for segregation purposes.

### Payroll

The form used in connection with the construction accounting payroll is a combined timesheet and payroll reg-

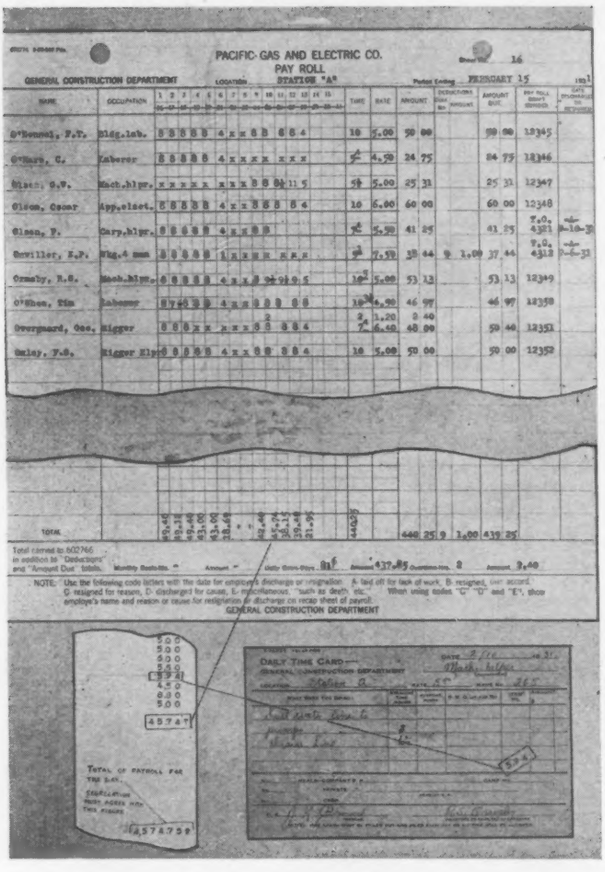



*Fig. 7. Daily time card and combined timesheet and payroll register. The adding machine total shown in the lower left hand corner provides a check against the total entered in the rate column*

ister. It is 11 in. wide and 14 in. long and accommodates 24 names to the sheet. It is the practice, however, to skip spaces occasionally when typing the names, occupations and rates in order to accommodate additions to the payroll during the period. It is prepared in duplicate, the original being forwarded to the accounting office and the duplicate retained in the field.

As the time is posted to the payroll each day, the amount earned is set up and added on a specially designed portable duplex adding machine. By inserting the time slips in a ticket chute located in front of the printing section of the machine, these amounts are printed on the time card and a tape simultaneously. As each payroll sheet is completed, a sheet total is printed on the tape, this being entered on the bottom of the duplicate sheet. A grand total of all sheets, which represents the total payroll for the day, is carried in the machine and is also printed on the tape upon completing the recording of the time slips. This grand total is entered on a control sheet and is used to balance the daily labor segregation.

Overtime hours are posted in the upper bracket of the space provided for each man. The overtime is interpreted into money and the earnings for the day are shown on the time card. This also applies to instances where less than eight hours are reported. Such earnings are also noted on the duplicate payroll sheet, so that fractional cents may be adjusted to enable the balancing, to the exact cent, of the labor distribution with the payroll.

Proof that correct rates are applied to the time cards is obtained by comparing the daily adding machine total entered on the bottom of each payroll sheet with the total appearing in the rate column, making allowances for absences, short hours and overtime, that may have been recorded. At the end of each pay period, the earnings are extended and entered in the amount column of the payroll sheets. Each sheet is balanced separately; the total of the amount or earnings column must agree with the sum of the daily totals entered at the bottom of the duplicate sheet. These balance so consistently that the procedure has really become a routine matter.

Employees who resign or who are discharged during the pay period are paid by time checks. The time-check number in such instances is immediately entered on the payroll sheet. The resignation or discharge date, together with the code letter, is entered in the extreme right hand column, this information being transcribed from this record to the employment cards by the central accounting office of the general construction department. It is, of course, entered on the copy of the employment card maintained in the field. This procedure is direct and accurate and eliminates the necessity of preparing a separate notice which would only add to the accounting routine.

## Payroll Recapitulation

After the payroll sheets have been extended, the time and money are segregated between monthly, daily and overtime basis, these data being entered in the space provided on the bottom of each sheet. This information is subsequently recapped upon the form illustrated in Fig. 8. The original of this form is forwarded to the general construction department, together with the original payroll sheets.

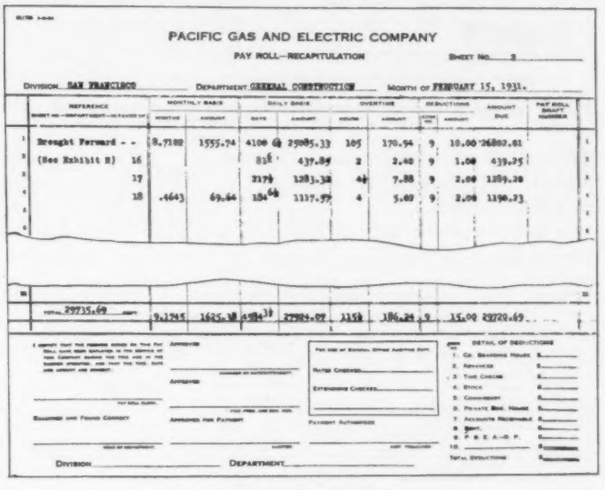



*Fig. 8. Payroll recapitulation.*

## Payroll Segregation

When the time slips have been posted to the payroll and approved by the various foremen, the job or item numbers are noted on them. Where the individual time is split between two or more accounts, amount of money to be distributed to each one is extended from a rate chart and entered on the cards. All time slips are then sorted into two classifications, those affecting but one account and those affecting two or more.

A unit ticket is created for each item of distribution appearing on the "split" time cards. A specially designed portable duplex adding machine is used for this purpose, the keyboard being split to permit the setting up of account number and amount simultaneously. After the unit tickets for an individual time card are created, a total of these tickets is printed on the time slip. This total is then checked with the figure printed on the card when it was posted to the payroll. This positively checks the accuracy of the

extension of split time in the simplest possible manner. This is illustrated in Fig. 9.

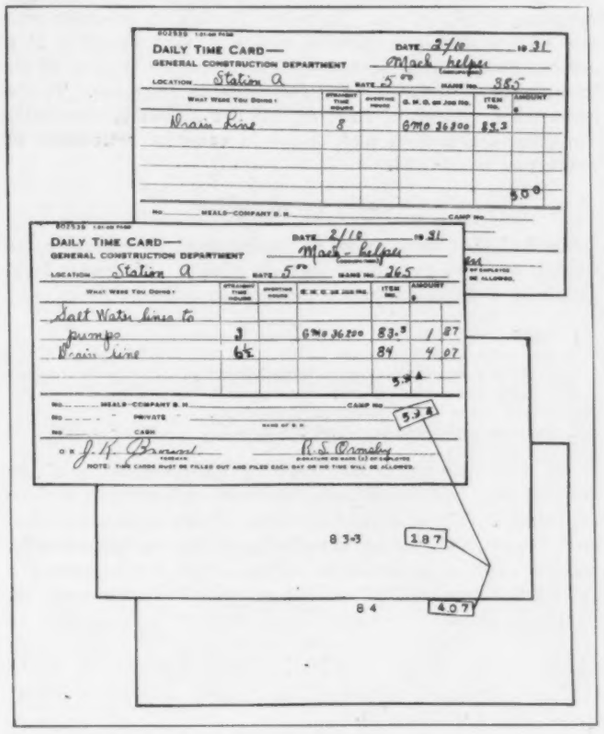



*Fig. 9 Above, time slip affecting but one account. Below, time slip affecting two accounts, with corresponding unit tickets.*

When the unit tickets have been created, they are sorted into job or item number order along with the time slips bearing a single distribution. They are then recapped on the duplex adding machine used on the payroll, unit tickets, individual totals of each account affected and a grand total of the entire distribution being obtained in this operation. (Fig. 10).

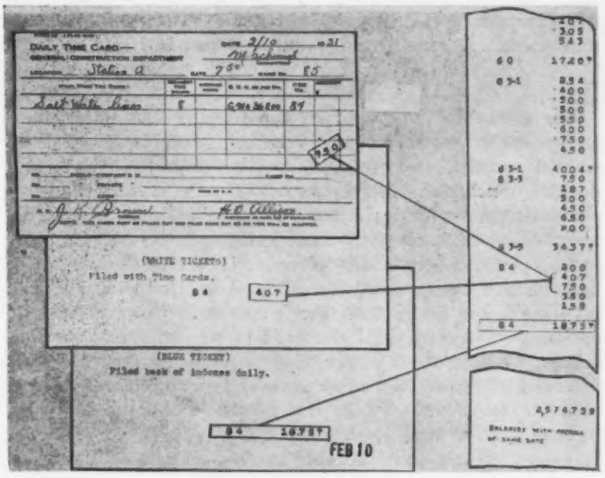



*Fig. 10. Daily time card with white and blue tickets and recap on duplex adding machine.*

The outstanding feature of this application is the manner in which the daily and monthly accumulation of labor charges to accounts is obtained. In the daily recapitulation of the labor distribution a blue unit ticket is created, as the total for each account is printed on the detail tape. This is made possible by a duplicator ribbon feature, permitting the printing to take place on two records simultaneously. The item number, having been added in the left section of the keyboard at the time the first amount was entered, prints automatically to the left of each account total. These blue summary tickets are dated and filed back of indexes set up for each job or item number. Since they are produced in numerical order, the filing operation is a very simple one.

On completing the recapitulation of each day's distribution, a grand total is taken on the detail tape and balanced to the cent with the total posted to the payroll. Due to the simplicity and directness of this operation, the grand total thus printed rarely fails to agree with the controlling figure. In the event of a discrepancy, the media are checked against the detail tape and the errors easily located. The tape is dated and filed with the time cards and subsequently becomes a permanent detailed record of the segregation.

At the close of each pay period the blue tickets, which represent the daily summary of charges by items, are recapitulated in the same manner as the daily work. White unit tickets are created, as the total for each item is taken. The grand total of these blue tickets, which is automatically accumulated during this recapping operation, is printed on the tape and balanced to the cent with the payroll for the period. Due to the fact that the segregation is proven each day, the grand total rarely fails to agree with the controlling figure.

The white tickets which represent the summary of charges by items for the pay period, are subsequently re-

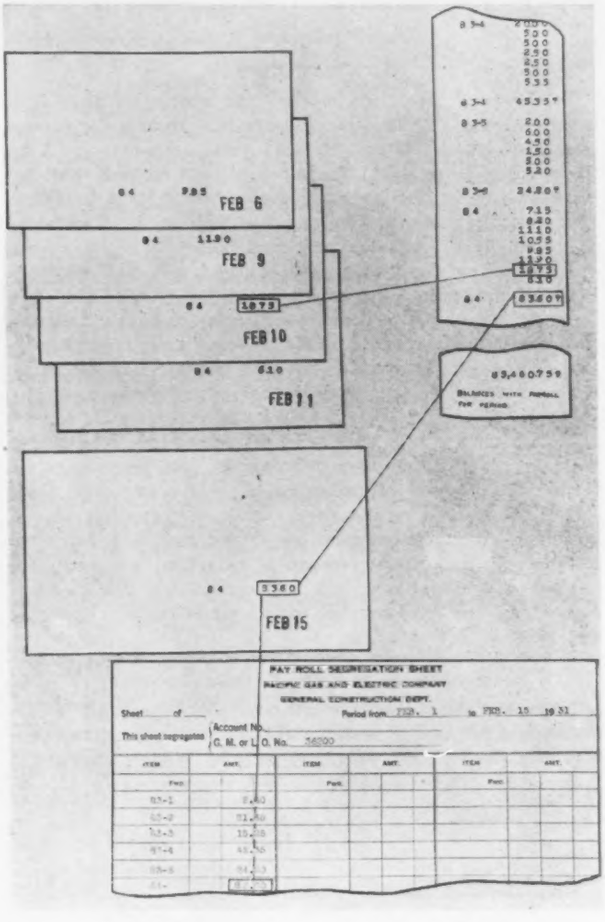



*Fig. 11. Form used for recap of white tickets.*

capitulated on the form illustrated in Fig. 11, the purpose of which is self-explanatory. The time required to prepare this summary has been materially reduced, resulting in this information being available much sooner than has been possible in the past.

Since the adoption of this method, our payroll and its distribution have been reduced to a mechanical process, and we have found that the efficiency of the men has increased to a point where one man is able, with no mental or physical strain, to post, balance, and segregate daily, and furnish those in charge with daily costs for a payroll of over 550 men.

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## *Fixed Capital Records**

*This report confines itself to a consideration of what fixed capital records should be kept, how they can be originated and why they should be maintained.*

THE committee appointed to consider fixed capital records discovered that it was necessary to do some pioneering in connection with this subject on the Pacific Coast, inasmuch as previous committees, if any, had failed to leave written reports of their activities. Therefore, the committee decided to confine its deliberations and investigations to a single phase of the subject which is covered by the fixed capital records committee work—that records of this character should be kept, how these records can be originated and why they should be maintained. The committee held one meeting in Los Angeles, which was attended by five of the seven members and at which several definite conclusions were reached.

### Where Kept

In the first place, we reached the conclusion that it is highly desirable to maintain fixed capital records for certain classes of capital, if not for all capital accounts, and that, other things being equal, these records can be kept most advantageously by the accounting department of a company. However, the organization and administration of some of our companies is so arranged that departments other than the accounting department are charged with the responsibility of producing data which become a part of the fixed capital records, and in these cases it may be highly desirable that the permanent fixed capital records be partially maintained, at least, by some division of the organization which is not connected directly with the accounting department.

We find that in nearly all companies some detailed records of equipment are kept outside of the accounting department. We refer particularly to meter records, pole records, transformer records, etc. However, in a great many cases these subsidiary records cannot function as fixed capital records, inasmuch as quantities only are shown and values are not considered. Subsidiary records of this kind are very valuable to the accountant, but they cannot take the place of fully completed fixed capital records showing both quantity and value.

### Importance of Fixed Capital Records

There are many good reasons why every company should maintain fixed capital records. In the first place, they support the fixed assets as shown on the balance sheet, and frequently they furnish invaluable data for rate hearings, insurance purposes, tax schedules, special reports and statements, annual and other reports to state and federal commissions, publicity, etc. They also furnish an adequate control of periodical inventories, which is very essential if a company expects to keep a somewhat correct record of its miscellaneous equipment and furniture and fixtures. To the accountant, records of fixed capital are almost indispensable for determining data and values in cases of retirement of plant and equipment.

### Types of Records

We find that some types of capital lend themselves more readily to detail recording than do others. The order from simple to difficult appears somewhat as follows:

1. Land.
2. Buildings and structures.
3. General equipment—furniture and fixtures.
4. Meters and transformers.
5. Power plant and substation equipment.
6. Overhead and underground lines.

The starting point for fixed capital records is either original cost and construction records or inventory and/or appraisal . We find that in most of our companies such records are available for a majority of the capital accounts.

Some form of job or work order system is necessary for the maintenance of fixed capital records, and such a system is already in use in practically all up-to-date companies.

The accounting requirements of the Federal Power Commission seem to make fixed capital records absolutely necessary for those companies which operate properties under license of the commission.

### Simple Forms Used

There is some question regarding the form in which fixed capital records should be kept, but our committee agrees that form is not so important, if only adequate records are maintained. Simple forms are considered best and loose leaf ledgers appear preferable to cards or bound volumes. We found that the Southern California Edison Company Ltd. maintains a very satisfactory fixed record for federal projects on a loose leaf form which is called "Plant Detail Ledger—Federal." This form has been in use for five or six years and lends itself admirably to original entry, either from inventory, fair value or construction records and also provides adequate cross reference for retirements, adjustments, etc. A copy of this form is shown in Fig. 1.

### Periodical Revision

The committee discussed at some length the question of how often it would appear to be necessary to renew fixed capital records, and we have not been able to reach any definite conclusion. Some accounts, such as miscellaneous equipment account, including furniture and fixtures, probably should be inventoried once each year, or possibly once in two years, and possibly after having reconciled these inventories to the control, a new fixed capital record should be opened, beginning with the inventory. However, this is optional. The fixed capital record of accounts such as substation equipment or power plant equipment accounts may become highly involved after several years of additions and retirements are shown in the record, and probably such records should be consolidated and rewritten periodically. However, it does not appear to the committee that this would be necessary any more frequently than every five years, and possibly longer periods would prove adequate.

Our committee has not been able to produce any estimates of the additional cost, if any, of keeping adequate fixed capital records. We are of the opinion that the saving of time from the intelligent use of such records will more than offset the nominal cost of maintaining them. The real ques-

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* Report of fixed capital records committee, Accounting Section. F. C. McLaughlin, Southern California Edison Company Ltd., chairman.
Los Angeles Gas and Electric Corporation: Manuel Sandusky.
Pacific Gas and Electric Company: P. C. Miller.
San Diego Consolidated Gas & Electric Company: C. W. DeVoe.
San Joaquin Light & Power Corporation: A. S. Walthall.
Southern California Edison Company Ltd.: C. N. Rudkin.
Southern Sierras Power Company: E. R. Sims.

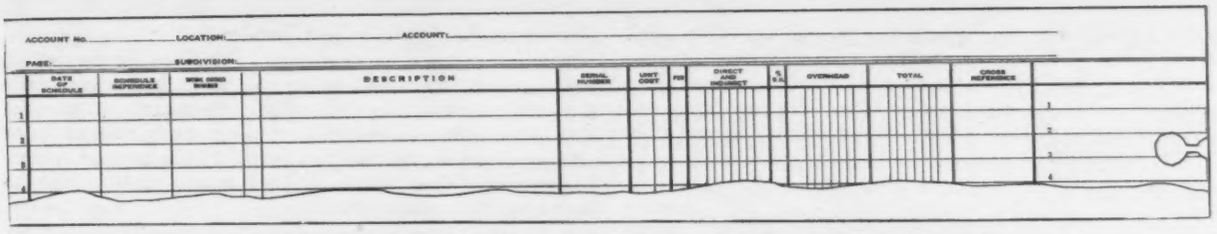


*Fig. 1. Loose leaf form which lends itself well to the keeping of fixed capital records.*

tion is not, "What will fixed capital records cost?" but rather, "How can we afford to be without adequate fixed capital records?"

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## *General Records**

*This committee has made itself familiar with the report of the national committee and found it in keeping with its views. After gathering considerable information from various sources and from our investigation, we submit a condensed report in the following comments.*

THE preservation and destruction of records is a matter which, in the past, has been given more or less indifferent consideration by practically all companies. There appears to be a considerable variance of opinion as to the importance of the subject under discussion and an apparent lack of any standard method of procedure for the handling of records. It was disclosed that formerly records had been filed indiscriminately in basements, old steam plants, or substations, where space could be spared, and that any endeavor to find them entailed an extensive search through boxes and bundles which might or might not reward the explorer with the record for which he was searching.

The investigation brought out the fact that only in recent years had serious consideration been given to the method of handling records by the respondent companies.

Having now provided adequate filing space for their records, these companies are now in the process of investigating the contents of their old files, destroying records which are of no use and arranging other records according to some systematic filing method.

### Standard Office Methods Committee

One of the respondent companies has organized a group of its employees into what is known as the "standard office methods committee," one function of this committee being the preservation and destruction of records.

The committee employs an investigator to make surveys of the current and the obsolete records of each department of the corporation, and with the aid of chief clerks and department heads, recommends the length of time that the original and each copy of all the various forms are to be retained, and how and where they are to be filed.

A set of forms is used by the investigator on which to accumulate all the information required from the various departments. This is used as a basis for his report and recommendation to the standard office methods committee.

This committee studies the various reports prepared by the investigator and it is this committee which finally passes upon the procedure to be followed in the handling of each record. A record of the committee's findings is then prepared in a consolidated form and is passed to the auditor and comptroller for final approval, after which it is published as the established regulations of the corporation for the handling of forms listed thereon.

It is apparent from our investigation that the committee is conducting this particular function of its work in a very thorough manner, and it is believed by all concerned that the expense of this effort will be more than repaid in increased efficiency in the organization on account of the facility with which records required may be obtained, combined with the saving in investment in filing equipment and storage space. Therefore we commend this plan to anyone seeking relief from these burdens.

### Internal Audits

The subject of internal audits and the procedure in use by the various companies were studied. Two procedures were gone into in detail and the methods of audits and internal check were investigated.

The audit report made after an auditor's investigation of the securities sales department of one of the respondent organizations was considered. This audit report covered an analysis made up of 30 schedules which showed in considerable detail the transactions that had been carried on through this securities sales department during the year—as to subscriptions to capital stock and disposition of the same through the records of the company, as to cash received on such subscriptions and the method in use to establish the fact that such cash received was deposited in a bank to the credit of the corporation, the amount of commissions paid, the accuracy of accounting for stock premiums and discounts, verification of amounts refunded to subscribers in cases of overpayment, etc., the accuracy of the distribution of both subscriptions and cash receipts on the books of this investment sales department, and, ultimately, the verification of the net balances shown on the books of the securities sales department with the controlling accounts on the general books of the corporation.

This audit comprised transactions running into a large volume of money and the amount involved was sufficiently great to warrant an expenditure of considerable time and effort to establish the accuracy of records under investigation. It was found that the audit report as submitted was complete in the verification of every controlling account shown on the general books of this corporation and was a satisfactory document, as shown below, to aid in the study of one form of internal audits.

### X-Y-Z Securities Sales Department Audit Procedure

*Capital Stock Issued—*

Totals of shares issued per transfer sheets are checked to a control summary. Monthly totals per control summary are compiled in the form of a schedule to obtain the total number of shares issued during the period under review. This total number of shares is then converted to the par value of the stock. The total par value of stock issued during the period is added to the amount outstanding at the close of the previous period, thus arriving at the total amount outstanding at the close of the period under review,

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* Report of the general records committee, Accounting Section. D. C. Griffin, Southern California Edison Company Ltd., chairman.
Los Angeles Gas and Electric Corporation: N. H. Bradshaw.
Pacific Gas and Electric Company: A. T. Kelley.
San Diego Consolidated Gas & Electric Company: C. G. Waters.
San Joaquin Light & Power Corporation: L. C. Streit.
The Southern Sierras Power Company: H. S. Barber.

which amount must agree with the general ledger balance. The number of shares outstanding is then reconciled with the number of shares shown on the certificate of the trust company acting as registrar. Adding machine tapes are run on the stock ledger balances and the totals agreed with control summary.

*Cash Receipts—*

Cashier's collection sheets, which are made up daily covering the day's collections, are checked to the daily summaries prepared by the head cashier. Totals of these summaries are checked against bookkeeper's daily cash posting sheets to see that they agree. The total cash shown on posting sheets is then checked to the ledger control summary and the monthly totals of the ledger control summary are set up in the form of a schedule to arrive at the total receipts for the period under review. A similar schedule is made up from the treasurer's cash book, showing the receipts reported to the treasurer during the period. Cash receipts per control summary are then reconciled with receipts per treasurer's cash book to account for any differences, such as cash in transit, etc. Deposits of these receipts to the credit of the company is established when the bank statement is received and reconciliation made with the cash book.

*Subscriptions—*

All subscriptions are entered in a register or "inventory," both as to shares and amount. Daily totals of the inventory are checked into the control summary and the monthly totals accumulated in the form of a schedule. The amounts used in the schedule are the par values. A similar process is used in auditing cancellations. The cancellations, together with value of stock issued, is set up in the same schedule with subscriptions. This schedule starts with stock subscriptions as at the beginning of the period, and after adding the subscriptions and deducting cancellations and issues, arrives at the amount of subscriptions at the end of the period, which is checked against the general ledger balance.

*Subscribers—*

The subscribers' accounts are charged with the original subscriptions and credited with cancellations and with cash applied on the subscription. These items have been explained in previous paragraphs. Subscribers' accounts may also be charged with cash refunded to them in case of cancellation, overpayment, etc. Refunds and cancellations are checked from the schedule on the journal entries, canceling the subscriptions to the account in the subscribers' ledgers, verifying the price at which the stock was subscribed and the discount or premium adjustment shown. The amounts shown as refunded are checked against the checks making the refunds. The checks are then scanned to see that they are indorsed by the payee.

Details of transfer between classes of ledgers, dividends set up and canceled and other miscellaneous adjustments are carefully checked to their proper accounts.

All charges and credits affecting subscribers' ledgers are checked to the control summary and the monthly totals are then set up in a schedule. This schedule sets forth the balance at the beginning of the period, the transactions as outlined, and the balance at the end of the period, which is reconciled with the balance per general ledger.

Adding machine tapes of subscribers' balances are run as of the last day of the period and the totals checked with the balances per control summary.

All transfers between the various classes of ledgers are checked to the individual accounts from the journal entries. These transfers, together with transfers between alphabetical subdivisions of the same ledger, are set up in a schedule and the debit and credit equality established.

Totals of all records in the securities sales department which enter into the general ledger balances are verified by a comptometer operator.

*Contingent Fund and Cash on Hand—*

The contingent fund is verified at the end of the period under review. This verification consists of counting all cash and items of disbursement, adding thereto the balance in bank per check register, and agreeing the total with total amount of contingent fund as shown by the general ledger. The general ledger balance is then reconciled with balance shown on bank statement.

Cash advanced to cashiers, as well as amounts received on account of stock subscriptions, are verified by actual count.

*Treasury Bonds—*

At times bonds are sold direct to the public by the investment sales department. The sales as shown by the investment sales department register are checked to the receipts issued by salesmen, care being exercised to see that the purchasers receipt for the bonds when delivered. Total amount of bonds sold are tied in to the bond record in the accounting department and unsold bonds are verified by certificate from the custodian.

Another audit given consideration was the report of the construction of an office building recently erected by one of the corporations responding. The accounting system of the contractors was used as a basis for the first exhibit in this report. Supporting schedules were prepared by the auditors, showing the relation of the expenditures as shown on the books of the corporation to accounts as carried by the contractors, together with reconciliations between the two sets of accounts. This form, with comments, follows:

### X-Y-Z Company Audit Procedure—A-B-C Company, Contractor for New Office Building

A balance sheet as taken from the books of the contractors is here given, the items being as follows:

*Debits—*
- Cash in banks
- Force account payments
- Contractor's fee
- Specialty contracts made
- Sundry accounts receivable

*Credits—*
- Advances from X-Y-Z company
- Balances due on uncompleted contracts
- Sundry accounts payable.

Supporting schedules prepared by auditor were as follows:

A Statement of expenditures and reconciliation with ledger
B Specialty contracts
C Reconciliation—statement of expenditures with balance per bank
D Adjustments between ledger and statement of expenditures
E Bank reconciliations
F Accounts receivable
G Accounts payable.

The building was erected on a cost plus basis, advances being made to the contractor by the X-Y-Z company as needed. About the 15th of each month, after closing the books for the previous month, the contractor rendered a statement of expenditures, setting forth advances received by them from the X-Y-Z company and deposited in a special account or "revolving fund," amounts expended on their own or "force account" work, payments to specialty contractors and contractor's fee, computed as percentage of the total expended by the contractor.

The data shown on statements of expenditures were set up in Schedule A. The balance in revolving fund as shown by this schedule was reconciled with the balance per bank statement as of the last day of the preceding month, Schedule C.

Inasmuch as approximately half a month would elapse between the ledger closing date and the date of statement of expenditures, the necessary reconciliation was made on Schedule A to bring the totals of force account payments,

payments on contracts, fee account and advances from X-Y-Z company into agreement with the ledger balances. These adjustments were listed in detail on Schedule D, and the total adjustment listed on Schedule A.

Specialty contracts are set up in Schedule B, showing amount of contract, payments thereon and balance due. The total amount of contracts supports item of "specialty contracts made" on balance sheet, while the total of the balances of the various contracts covers the balance sheet item "balances due on uncompleted contracts." The total of payments made on contracts agrees with the adjusted totals of amounts expended on contracts in Schedule A.

Cash in bank was reconciled with balances per bank statements and set up as Schedule E.

Accounts receivable consist of charges to contractors and material sent to other jobs for which payment has not yet been made to the revolving fund.

Accounts payable are in the nature of material received from other jobs for which payment has not yet been made.

These two items are supported by Schedules F and G respectively.

The audit procedure consisted of checking all invoices to see that they were OK'd by the job auditor and material clerk, that extensions and footings had been verified, that materials and services billed were for the X-Y-Z company job, that all discounts had been taken and that the invoices agreed with the material clerk's requisitions. In checking invoices to requisitions, particular attention was paid to the firm name, quantities, prices, discounts and that the job superintendent's OK appeared on the requisitions. Invoices covering progress billings, account of specialty contracts, were checked against notices of completion in the contractor's office, also against total of contract, plus or minus changes, to see that payments were not made in excess of the contract.

Following the above procedure, invoices were checked to their respective vouchers, vouchers were scanned for proper approvals and were then checked against the items listed on statements of expenditures made to X-Y-Z company by the contractor, special care being exercised to see that no items were listed on these expenditure statements that would not be chargeable to the building construction and properly be included in the base upon which the contractor's fee was computed. The contractor's fee was then checked against this base.

Payrolls for two weeks in each month were checked against the daily time sheets. Payroll checks were scanned for indorsement and checked in detail against the payrolls.

Rates of the various classes of labor were also checked. The X-Y-Z company representative occasionally functioned as paymaster, paying off the contractor's men for the purpose of detecting any attempt at payroll padding.

All returned checks drawn on the revolving fund were scanned for indorsement and checked against the items on the statement of expenditures rendered by the contractor.

This form of audit was found to be well arranged and complete in all its details. The committee selected this form as a model from which accounting of this kind could easily be arranged which would greatly facilitate a comprehensive audit.

Your committee is well aware of the fact that due to many matters which would have to be taken into consideration by the individual concern, it is quite impossible to establish procedure on any subject which could be satisfactorily applied in all cases. Therefore we have pointed out in a general way the necessity for a systematic and orderly plan of handling that subject of ever increasing importance—the preservation and destruction of records.

We have also discussed the most uncommon forms of internal audits only, for the reason that previous committees have dealt fully with those forms related to the operations of an electrical utility business generally, such as, for instance, revenues, operating expenses, capital expenditures, etc.

# Advertising Publicity Section[1]

*The Advertising-Publicity Section has this year carried out its work along similar lines to those followed for the past four years.*

THE Advertising Publicity Section of the P.C.E.A. has carried on its activities along much the same lines that have been followed for the past three or four years. A session of the section was held in San Francisco in October. The January session was held in Los Angeles and the April session in Fresno. Following the practice which has been established for some time now, the Advertising-Publicity Section has made its meeting dates and places coincide with those of the Commercial Section. This has permitted a ready interchange of ideas and has been conducive to the further development of the sales program of the industry.

The state-wide advertising program through weekly and monthly magazines, as in the past, has been handled by the Advertising-Publicity Section. This particular phase of the activity of the section has developed into a very important factor in our industry's growth.

Each month, each member of the section sends through a central clearing house a specimen of the type of advertising material which his particular company has been using during the preceding 30 days. This practice has proved to be extremely valuable in keeping everyone up and down the state thoroughly informed as to the activities of all other sections of the state and has made it possible for every member company to share in whatever new ideas may be developed in any part of the territory. The Advertising-Publicity Section is very much alive to the necessity for a broad outlook on problems which confront the industry and is prepared to take its full share of the work of meeting those problems. The section is numerically rather small, but this fact tends to engender a closer working relationship between its members and in this manner serves to strengthen the effectiveness of each.

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[1] R. G. Kenyon, Southern California Edison Company Ltd., chairman. E. P. Ramsey, Los Angeles Gas and Electric Corporation, vice-chairman.
Arizona Edison Company: M. G. Saunders.
Edison General Electric Appliance Company: P. H. Booth.
Electrical West: W. A. Cyr.
Electrical World: W. C. Heston.
General Electric Company: Fred Garrison.
Graybar Electric Company: C. L. Huyck.
Los Angeles Gas and Electric Corporation: D. L. Scott.
McGraw-Hill Publishing Company: J. W. Otterson.
Pacific Coast Electrical Association: K. I. Dazey.
Pacific Gas and Electric Company: A. M. Frost, J. C. Jordan, A. C. Joy, F. S. Myrtle.
San Diego Consolidated Gas & Electric Company: F. M. Raymond.
San Joaquin Light & Power Corporation: S. W. Green.
Southern California Edison Company Ltd.: W. L. Frost, R. E. Smith.
Southern Sierras Power Company: J. R. Gabbert.
Valley Electrical Supply Company: J. U. Berry.
Westinghouse Electric & Manufacturing Company: Donald McDonald, Earl Nilsson.

# Commercial Section[1]

## GENERAL BUREAU REPORTS[2]

### *Customer Relations*[3]

*During the association year* 1930-31 *the general bureau has been engaged in two activities conducted by the following committees: First, customers relations committee; second, Red Seal committee.*

THE function of the customers relations committee has been the promotion of an Essay Contest among employees of member companies. Essay contests have become an accepted feature of annual conventions and contribute materially to the education and information of all employees participating.

The subject of this year's contest is "The Electric Appliance—The Ideal Household Servant."

A booklet containing essential and pertinent information on the subject has been prepared and 12,000 copies are, at this writing, in the hands of company contest directors for distribution to employees desiring to enter the contest. An adequate supply of registration cards and posters has also been provided.

#### Wide Participation Anticipated

As this report is required prior to the date of the contest, it is obviously not possible to give details of the accomplishment. It is anticipated, however, that with the support of company executives as recommended by last year's General Bureau, employee participation will exceed that of previous years. As the number of contestants is the yardstick of the potential benefits to be derived from this activity, it is hoped our expectations will be realized. As a further incentive to employee participation, and continuing the plan of last year's General Bureau, 89 cash prizes of a total value of $900 will be awarded to the contest winners. In addition to this, special prizes will be awarded by many of the member companies.

The essay contest is under the supervision of Lloyd Henley, chairman, customers relations committee.

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[1] Executive Committee—E. G. Stahl, chairman, Frank Weiss, vice-chairman, George Bailey, G. T. Bigelow, O. S. Clifford, E. W. Florence, H. C. Goldrick, A. F. Morairty, W. C. McWhinney, R. W. Turnbull, Pierre Vinet, J. W. Wrenn.

[2] D. C. Ray, Pacific Gas and Electric Company, chairman. L. Henley, San Joaquin Light & Power Corporation, vice-chairman.
General Electric Company: G. S. West.
General Electric Supply Corporation: F. C. Todt.
Los Angeles Gas and Electric Corporation: C. Bennett, D. L. Scott.
Pacific Gas and Electric Company: F. S. Curren, E. M. Seel.
Pacific Public Service Company: J. M. Lloyd.
San Diego Consolidated Gas & Electric Company: A. May.
Sierra Pacific Power Company: G. A. Campbell.
Southern California Edison Company Ltd.: W. P. Graef, G. M. Rankin.
The Southern Sierras Power Company: A. G. Cage.
Tucson Gas Electric Light & Power Company: A. E. Morrison.
Vallejo Electric Light & Power Company: E. B. Pierce.

[3] Report of customer relations committee included in general bureau report, Commercial Section. L. Henley, chairman. A. G. Cage, G. A. Campbell, W. P. Graef, J. M. Lloyd, A. May, A. E. Morrison, E. B. Pierce, D. L. Scott, E. M. Seel.

### *Red Seal Work in California**

*The primary function of this committee has been to co-ordinate the forces of the utility companies with the work initiated and carried on by the California Electrical Bureau, now the Pacific Coast Electrical Bureau. Mr. Rankin's report which follows, speaks for itself and has the unanimous indorsement of the general bureau.*

THE Red Seal committee for 1930-31 has functioned in conjunction with the newly reorganized Pacific Coast Electrical Bureau, and in this way has endeavored to do whatever possible to stimulate the Red Seal action in the various districts.

The new organization places the Red Seal work under the direction of three major committees of the Bureau and these committees have been carefully selected to the end that the members should represent all branches of the industry and that the fullest possible coverage of the territory be obtained.

All three of these regional committees have met, duties have been assigned to the various subcommittees and members, and the work is reported as being well under way.

#### Reorganizing Work

The cessation of Red Seal effort in some districts of California during 1930, which was so clearly shown by the falling off from 2,768 Red Seal applications in 1929 to 1,876 in 1930, will necessitate a sustained continuous effort for several months before we expect to overcome the inertia and produce any appreciable results.

Some, and possibly many of the architects and builders, who through Red Seal work prior to 1930 were persuaded to embody the Red Seal specifications in their plans, will doubtless have continued to do so, to some extent at least, during 1930, and with the re-establishment of a Bureau field staff a number of such jobs will probably be brought to light which have never been reported.

On the other hand, the architect or builder who was unable to obtain Red Seal service for his work during the past year, may have to be entirely re-sold on the plan, and the very cessation which makes this necessary is also going to make it difficult.

#### Domestic Load

Your committee commends the Red Seal activity to the attention of the executives of each and every member company as one of the most effective means of increasing the domestic consumption of kilowatt-hours.

We believe the time has come for the utility companies to to get strongly behind some comprehensive, sustained activity for the purpose of selling more wiring and better wiring, for it is only by means of such an effort that we may expect to break the existing bottle-neck of the inadequate wiring installation and develop to the fullest the very valuable and desirable domestic lighting and appliance load.

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* Report of Red Seal committee, general bureau, Commercial Section. G. M. Rankin, chairman. C. Bennett, F. S. Curren, F. C. Todt, G. S. West.

The Red Seal plan offers just such a program, and with the recent addition of the Red Seal specifications for wiring in commercial buildings, the field is expanded to cover practically every type of building except the industrial.

The residential Red Seal job has definitely shown an increase in revenue to every branch of the industry, and the commercial Red Seal wiring installation offers an increase equal, in proportion to the size of the job, to that shown by the residential Red Seal job.

### Co-operation

One point should be clearly understood, however; the Red Seal plan cannot function satisfactorily without the fullest co-operation from the personnel of the utility companies.

By this is meant that every power company salesman should feel that the promotion of the Red Seal program is as much a part of his duties as is the sale of kilowatt-hours or ranges.

It has been the usual experience that the success or failure of the Red Seal work in any given territory is a direct reflection of the amount of effort put into it by the utility company serving that district, and to obtain this effort and to be assured of the co-operation of the man in the field, it is absolutely essential that the plan have the full support of the company executives.

Where this support has been given fully the Red Seal program has prospered, but where it has been withheld, the plan has fallen by its own weight.

The last few months have shown increasing interest on the part of the executives and it is the recommendation of this committee that this support be maintained and continued, for without it the Red Seal activity in California must surely fail.

# LIGHTING BUREAU REPORTS[2]

## *Educational Lighting**

*As with others of the lighting committees, activities this year have been directed toward the publication of a series of magazine articles.*

DURING the past year the efforts of the educational lighting committee have been directed toward the preparation and publication of a series of magazine articles advancing the interests of better lighting.

Several co-operative promotional programs were discussed at the first meeting of the committee, but it was felt that most of those proposed would in a measure duplicate efforts already being made through other channels and that the interest of all concerned would be best served through a campaign of publicity. Such a campaign was therefore undertaken for the work of this committee for the year.

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[2] G. H. P. Dellman, San Diego Consolidated Gas & Electric Company, chairman.
Curtis Lighting, Inc.: J. C. Lauderdale, R. D. Meyers.
Edison Lamp Works: Clark Baker, W. E. Carlson, E. P. Markee.
Electrical West: Wm. Cyr.
General Electric Company: Carl Koch, H. B. May, L. G. Gianini.
General Electric Supply Corporation: F. E. Nightingale.
Graybar Electric Company: C. L. Huyck.
Edwin F. Guth Company: L. A. Hobbs.
Holophane Company: Frank Hanson, George Rucker.
Los Angeles Bureau of Power & Light: O. W. Holden, F. D. McKinstry.
Los Angeles Gas and Electric Corporation: R. A. Crosby.
Pacific Coast Electrical Association: V. W. Hartley.
Pacific Gas and Electric Company: W. P. Bear, Frank Bevan, W. H. Hambridge.
San Joaquin Light & Power Corporation: J. E. Hammond.
Southern California Edison Company Ltd.: C. D. Lindley, W. L. Moreland, G. M. Rankin, M. L. Saunders.
The Southern Sierras Power Company: L. F. Hallett.
Tucson Gas, Electric Light & Power Company: J. F. Hartin.
Vallejo Gas & Electric Company: E. B. Pierce.
Westinghouse Electric & Manufacturing Company: H. S. Warren, F. J .Wellhouse.
Westinghouse Lamp Company: R. W. Buckles.

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* Report of the educational lighting committee, lighting bureau, Commercial Section. Clark Baker, chairman. Frank Bevan, W. A. Cyr, W. E. Carlson, V. W. Hartley.

## *Home Lighting**

*The committee submits recommendations on the subjects of employee education, advertising and publicity, promotion of adequate wiring and promotion of the sale of indirect portable lamps.*

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* Report of the Home Lighting Committee, lighting bureau, Commercial Section. G. M. Rankin, chairman. W. E. Carlson, R. A. Crosby, J. F. Hartin, E. P. Markee, F. D. McKinstry, E. B. Pierce.

IN SURVEYING its field of activity, the home lighting committee came to the conclusion that the work assigned to it could best be covered if divided up into four activities, as follows:

1. Employee education
2. Advertising and publicity
3. Promotion of adequate wiring
4. Promotion of the sale of indirect portable lamps.

Your committee herewith submits recommendations for the carrying out of these four activities.

### Employee Education

In order properly to sell the idea of better home lighting to our consumers, it is essential that those on whom this work will fall should know their subject.

A large quantity of excellent material is available at the present time, produced by various sources.

One of the Mazda lamp companies has recently issued a correspondence course in home lighting. This is very concise and clear and is an excellent piece of work; the data it contains should be very useful to every employee of a utility who contacts the consumer of residential kilowatt-hours.

Another lamp company has issued a very complete set of booklets, fifteen in nnumber, covering various phases of residential lighting. These are particularly suitable for use by lighting salesmen, as they cover the field in much more detail than any other similar material we have yet seen.

The same company has issued a set of nine smaller booklets, each one of which may be followed by a questionnaire covering the points brought out in that particular book. These should be excellent for use among the counter men, telephone operators, appliance salesmen, appliance repairmen, meter men, trouble men—in fact, any employee who contacts the residential consumer.

These booklets may be issued to the employees in question about every two weeks, each book followed at an interval of one week by the questionnaire; these, in turn, may be collected and graded and a prize offered for the employee making the best grade.

Other valuable and interesting material is also available, of which that mentioned in the preceding paragraphs is just an example.

### Advertising and Publicity

Your committee recommends that more newspaper and magazine space be devoted to home lighting.

The commercial and industrial consumer knows that the utility employs lighting experts, because they have called on him, but the average domestic consumer who, incidentally, needs the assistance of the lighting expert fully as much as the storekeeper or the manufacturer, has no knowledge of the fact that this assistance is available. When he gets the information from his evening paper, under his inadequate lighting, it gives the lighting man an entree that he could obtain in almost no other way.

Some of the member companies have done some notable work along this line; one in particular uses a series of ads showing a house without a roof, another a house without doors, another without windows, floors, etc., pointing the moral that a modern, adequate lighting job is fully as essential as the features missing in the drawing, and calling the reader's attention to the fact that the electric light company employs lighting experts to help him in lighting or relighting his home.

We also circularize the commercial and industrial consumer and tell him about what better lighting can do for him, but when we mail any sales material to the residential consumer, it is usually in regard to investments or heavy duty appliances. Both of these are excellent activities, but why not mail him a letter telling him about better lighting in the home—for his own comfort, for his wife's convenience, for his children's eyesight? It should be distinctly worth while.

The Society for Electrical Development offers a fine assortment of letters and booklets, and various manufacturers and several of our member companies have done some excellent work along this line. This activity, wherever used, has paid dividends to the user.

#### Promotion of Adequate Wiring

This field of activity is absolutely essential if the home is to be properly lighted and this committee believes that the excellent work being done along this line by the Red Seal committee and the Pacific Coast Electrical Bureau should be aided and supported in every way possible, since without an adequate wiring installation in the home, it is absolutely impossible for the owner or occupant to obtain the complete modern lighting so essential to comfort, convenience and the conservation of eyesight.

This Red Seal activity is therefore commended to the attention of the executives of our member companies for their whole-hearted support and co-operation.

#### Promotion of the Sale of Indirect Portable Lamps

The modern, indirect portable lamp has a universal appeal, as it is decorative, either when burning or when turned off, it gives a good general intensity of light with a complete absence of glare, and the prices, formerly prohibitive, have been reduced to a level within reach of anyone.

The sale of this type of equipment is much simpler than an elaborate refixturing campaign, as it entails no wiring in most cases, and even when additional wiring becomes necessary, it is a comparatively simple matter to run in an extra convenience outlet or two.

These portable lamps use 200 and 300-watt lamps, and their more general use will naturally tend to break down, in the mind of the consumer, the inhibition which now exists in regard to lamps of this size.

Whether this equipment is to be sold by the utility or the dealer, is, of course, a matter to be decided by the individual member company, but here is a piece of equipment which gives excellent results from a lighting standpoint and at the same time helps greatly to develop the domestic lighting load.

## *Sign and Outdoor Lighting**

*The following brief statement covers the activities of the sign and outdoor committee during the past year.*

THE sign and outdoor lighting committee made a study of power factor correction on gas tube signs and recomdations were made to manufacturers of signs for the correction.

* Report of sign and outdoor lighting committee, lighting bureau, Commercial Section. F. E. Nightingale, chairman. R. W. Buckles, W. E. Carlson, W. L. Moreland.

## *Commercial Lighting**

*The following brief report covers the activities of the commercial lighting committee for 1930-1931.*

DURING the past year the efforts of the commercial lighting committee have been directed toward the preparation and publication of a series of magazine articles advancing the interest of better commercial lighting practices.

Several co-operative promotional programs were discussed at the first meeting of the committee, but it was felt that most of those proposed would in a measure duplicate efforts already being made through other channels and that the interests of all concerned would be best served through a campaign of publicity. Such a campaign was therefore undertaken for the work of this committee for the year.

* Report of commercial lighting committee, lighting bureau, Commercial Section. J. E. Hammond, chairman. R. W. Buckles, R. A. Crosby, L. F. Hallett, Jess Lauderdale, C. D. Lindley, R. D. Meyers.

## *Industrial Lighting**

*Much of the time of this committee this year was spent in the preparation of articles for publication. In addition a study was made of bare neutral wiring and of some means of putting over the story of lamp voltage as against life and efficiency.*

THE industrial lighting committee undertook three objectives for this year, namely:

The preparation by the commercial members of the committee of a series of articles on industrial lighting. Publication of these articles was assured by the educational committee under Clark Baker.

A study of bare neutral wiring.

The development of some means of putting over the story of lamp voltage vs. life and efficiency.

The members of this committee prepared six articles on industrial lighting jobs and from time to time turned them over to Mr. Baker. One article secured publication direct.

The committee feels that some solution for the present rewiring problem must be reached, other than junking existing wiring and beginning anew with larger conduit, wire, etc. A small or even medium sized job will seldom bear this expense. The consumer wants better lighting, but objects to an expenditure of this magnitude. At the recent convention of electrical inspectors in New York, bare neutral

* Report of industrial lighting committee, lighting bureau, Commercial Section. R. A. Crosby, chairman. L. G. Gianini, W. H. Hambridge, J. E. Hammond, Frank Hanson, C. L. Huyck, J. C. Lauderdale, M. L. Saunders, H. S. Warren.

wiring was approved under certain conditions, from the service head to the main switch. Bare neutral has not been generally approved and the committee does not wish to go on record as indorsing bare neutral at this time. The committee does feel, however, that a further and more detailed study of bare neutral wiring, with particular reference to rewiring problems, may point the way to some solution, and wishes to make this as a suggestion for continued activity for next year's committee.

The third objective has not received the same attention as the other two. In the northern part of the state, group meetings with the electrical contractors have been held and some progress shown. The committee feels that this is worthy of further study.

In conclusion, the industrial lighting committee feels that immediate additional revenue from the industrial field will come, not from new and larger plants, but from remodeling and redesigning existing structures and lighting equipment, and that any and all means of bringing the benefits of better lighting to the attention of plant managers, production superintendents, etc., should be employed. It is realized that local conditions will determine ways and means of approach, but that we have right here a large size industrial lighting job.

## *Street and Highway Lighting**

*A comprehensive program has been laid out which will be continued by succeeding committees.*

IN ANALYZING the work which lay ahead as a committee program to further the interest of highway illumination, it was decided that there were four consecutive steps to be taken as follows:

1. Accumulate all available data for a comprehensive report of highway lighting installations existing at the present time in this state.

2. Tabulate a list of bad turns or other hazardous locations on the highway system which could advantageously and economically be lighted from existing facilities.

3. Prepare specifications and recommendations for the illumination of the above listed "dark spots" and proceed to promote these installations, either as individual company activities or as a committee activity as individual conditions may dictate.

4. Proceed with a comprehensive program to direct attention to the improvements resulting from the proper lighting of these bad places using these instances as illustrations of the need for, and benefit to be derived from, a general highway lighting program.

During the past year the committee has concentrated upon the first step and its efforts have resulted in the gathering together of a comprehensive file of information concerning practically all of the highway lighting jobs now in existence in California. These data are ready to be turned over to the incoming committee in order that they may proceed with the program above outlined, the ultimate purpose of which is the acquiring of facts and figures which will provide irrefutable proof of the importance of highway lighting, not only as an added comfort to the motorist and to level off the present daytime peak of travel, but as a very definite factor in adding to the safety of night travel.

* Report of street and highway lighting committee, lighting bureau, Commercial Section. V. W. Hartley, chairman. W. P. Bear, Carl Koch, O. W. Holden, H. B. May, G. M. Rankin, Geo. Rucker, Clark Baker, F. J. Wellhouse, G. H. P. Dellman.

# MERCHANDISING BUREAU REPORTS[2]

## *Appliance Merchandising**

*The outstanding topics of discussion of the appliance committee covered radio interference, co-operative utility advertising, trade relations and new appliances.*

THAT an increased amount of electrical interference in radio reception is caused by thermostatically controlled heating appliances and series motor driven devices, was generally accepted and regarded as a matter of vital importance.

It was established that with the installation of relatively inexpensive condensers or filters, which could easily be installed at the factories, such interference could very easily be eliminated.

### Action Needed on Radio Interference.

The necessity of immediate action in respect to this important matter was brought out by the fact—

1. That numerous ordinances are already in force in California, prohibiting the use or sale of electrical appliances which created radio interference, and that additional similar ordinances are constantly being adopted in other cities.

[2] H. H. Courtright, Valley Electrical Supply Company, chairman.
American Bakery Equipment Company: H. W. Sterling.
L. H. Bennett Company: L. H. Bennett, Edwin Pierce, F. M. Rowles.
Central Arizona Light & Power Company: R. A. Best.
Coast Counties Gas & Electric Company: N. E. Paulson, Pierre Vinet.
Dohrmann Hotel Supply Company: Stanley Perkins.
Edison General Electric Appliance Company: C. E. Allen, H. F. Huggins, P. H. Robinson, R. W. Turnbull.
Electric-Kold Company: Fred Salt.
Electrical Merchandising: Miss Clotilde Grunsky.
Electrical West: Wm. Cyr.
Electromaster: C. F. Edwards.
Everhot Electric & Manufacturing Company: H. H. Fogwell.
Ford, Bacon & Davis: Frank Ford.
Foulkes Electric Company: Roy Foulkes.
Frigidaire Sales Corporation: T. J. Supplee.
General Electric Supply Corporation: W. W. Gerster, A. W. Krueger, F. C. Todt.
Harold Gerber, consulting engineer.
Graybar Electric Company: H. C. Goldrick, R. W. Kimberlin, A. H. Nicoll.
Hoffman Specialty Company: H. H. Daley.
Ernest Ingold, Inc.: Ernest Ingold.
Johnson Washer Company: R. E. Kortepeter, G. B. Schuyler.
Linderman-Hoverson Company: Harry Lippert.
Listenwalter & Gough: Phil Gough, C. E. Louis.
Los Angeles Bureau of Power & Light: A. W. Elliott.
Los Angeles Department of Electricity: R. H. Manahan.
Los Angeles Gas & Electric Corporation: Frank Moon.
Majestic Electric Appliance Company: H. W. Smith.
Midland Counties Public Service Company: G. V. Footman.
Pacific Gas and Electric Company: A. A. Anderson, W. P. Bear, L. J. Brundige, O. R. Doerr, E. W. Florence, Philip George, Frank Kiefer, E. F. Perkins, B. W. Reynolds, L. D. Sherman, Emmett Ward, J. W. Wrenn.
Radio: A. H. Halloran.
R.C.A. Radiotron, Inc.: F. A. Mulvaney.
Radio Victor Corporation: B. C. McDonald.
San Diego Consolidated Gas & Electric Company: Edwin Meise, P. P. Pine.
San Joaquin Light & Power Corporation: E. J. Crawford, P. B. Wilson, G. E. Zelhart.
Sierra Pacific Power Company: O. S. Clifford.
South Wesix Company: M. L. Hooper.
Southern California Edison Company Ltd.: A. W. Althouse, L. A. Bartlett, C. M. Campbell, H. H. Douglas, C. N. Elgan, A. W. Frost, C. E. Hewes, J. C. Hoyt, J. D. Mercer, Myron McNeal, L. A. Phillips, M. W. Phillips, H. C. Rice, H. E. Welsh.
The Southern Sierras Power Company: W. S. Fleming.
Standard Electric Stove Company: C. C. Smoot.
Thompson & Holmes, Ltd.: W. J. Aschenbrenner.
Thor Pacific Company: Louis Swenson, E. O. Thomas.
Vallejo Electric Light & Power Company: R. C. Bragg, Edwin Pierce.
Valley Electrical Supply Company: R. W. Downing.
Wesix, Inc.: L. A. Krieg, H. V. Mooney, C. A. Russell, A. Strauch.
Westinghouse Electric & Manufacturing Company: H. L. Garbutt, J. H. Jamison, R. F. McDonald.
Westinghouse Electric Supply Company: J. A. Duncan, R. McDonald.
Westinghouse Lamp Company: R. W. Buckles.

* Report of appliance committee, merchandising bureau, Commercial Section. A. W. Althouse, chairman. R. A. Best, L. J. Brundige, O. S. Clifford, A. W. Elliott, A. W. Frost, Miss Clotilde Grunsky, R. W. Kimberlin, A. W. Krueger, C. E. Louis, R. F. McDonald, Edwin Meise, H. W. Smith.

2. That the police powers enforcing these ordinances are being rapidly perfected.

3. That radio broadcasts sponsored by the Radio Trades Association interference departments are giving negative publicity to electrical appliances, due to this unnecessary interference.

Already two manufacturers of drink mixers and juice extractors have definitely announced a policy of installing filters in appliances of their manufacture, which will permit them to guarantee elimination of radio interference.

Upon recommendation of this committee, the directors of the Pacific Coast Electrical Association unanimously passed the following resolution:

RESOLUTION OF DIRECTORS OF PACIFIC COAST ELECTRICAL ASSOCIATION

*Whereas,* the matter of radio interference caused by certain domestic electrical appliances is assuming a constantly increasing importance, as evidenced by (1) the report on that subject made by the appliance committee of this association at its San Francisco conclave, held October 23rd and 24th, 1930; (2) by the fact that many cities are passing and taking steps to enforce ordinances prohibiting the sale and use of such appliances, and (3) by educational talks broadcast by radio in many cities by the Radio Trades Association, condemning those domestic appliances that are responsible for such interference, and

*Whereas,* publicity of the character mentioned will no doubt be increased, thereby restricting the use and sale of such appliances, unless steps are taken to equip series motor driven and thermostatically controlled appliances, and any and all other appliances causing such interference, with proper filters or condensers, stamping on the nameplate of such appliances "non-radio interfering" or words of like effect, and

*Whereas,* it is to the mutual interest of both the manufacturer of and dealer in household electrical appliances and of public utility companies distributing electric energy, that radio interference from such sources, and publicity in regard thereto, be not permitted in the future to discourage or restrict the use and sale of electric appliances which have in the past done so much in contributing toward the welfare of such manufacturers, dealers and public utilities and the consumers of such utilities:

*Now, Therefore, Be It and It Is Hereby Resolved,* that the National Electric Light Association be requested to give its attention to ways and means of eliminating radio interference of the character above referred to, and that to that end it be urged to address all manufacturers of electric appliances causing or likely to cause radio interference, (for example, drink mixers, hair dryers, vacuum cleaners, fans, washing machines, juice extractors, vibrators, heating pads, air heaters thermostatically controlled, etc.), requesting the immediate co-operation of such manufacturers in manufacturing only such appliances as will not cause radio interference, and that said National Electric Light Association be further requested to suggest to the National Electrical Manufacturers Association the seriousness of the situation above referred to, and to request their immediate co-operation toward curing the difficulties, further suggesting to said National Electrical Manufacturers Association, that appliances not causing interference be advertised as "non-radio interfering."

*Be It Further Resolved,* that the National Electric Light Association be urged to request all other geographic sections of that organization to direct communications to all manufacturers of electrical appliances in their respective territories, and to the distributors therein, making similar suggestions to such manufacturers and distributors.

*Be It Further Resolved,* that the member companies of this association be urged to consider seriously the advisability of using their best endeavors toward effecting the discontinuance of the use and sale (especially through their own organizations) of such radio interfering appliances.

*Be It Further Resolved,* that copies of this resolution be sent (1) to the member companies of this association; (2) to the National Electric Light Association; and (3) to electric trade journals published in the territory in which this association operates.

### CO-OPERATIVE UTILITY ADVERTISING

At the San Francisco conclave meeting last October, the committee recommended that all utility companies use a portion of their advertising budgets for periodic concentrated drives on small appliances at list prices, prominently tying in all retail merchant outlets, for the dual purpose of creating a better understanding between the dealer outlets and the utility companies, and also, perhaps primarily, to utilize to the fullest advantage hundreds of electrical dealer stores and electrical department outlets in larger merchandising establishments, which have not been giving concentrated effort in using planned campaigns for the sale of small appliances. If each of these outlets could be stimulated to increase its appliance output by even a small percentage, the total number of current consuming devices in the home could be very materially increased.

One company has definitely adopted this plan, with very good results. It devoted one full side of its appliance campaign bill stuffers to advertising other makes of appliances than the one it was featuring itself, which gave the dealers a tie-in, utilizing the merchandise already on their shelves.

It is urgently recommended that all utility companies adopt some similar co-operative plan to enlist the full support of all electrical appliance outlets.

### TRADE RELATIONS

It is essential that during any power company's activities, the dealers be taken in on an equal basis. Such steps are recommended as: Making possible the purchase by any electrical dealer of the appliances to be featured by the power company at a price which will enable the dealer to obtain his profit, definitely including outlets in newspaper and bill stuffer advertising, making personal calls on the dealers, thoroughly familiarizing them with the plan.

It is equally important that the jobbers' and manufacturers' representatives be informed of any co-operative campaigns, in adequate time to permit of their planning ways and means of increasing the dealer volume on their particular brand of appliances, and otherwise stimulating interest in the activity.

### NEW APPLIANCES

From time to time there appear on the market new electrical appliances, many of which are very attractive as well as practical. It is a recommendation of this committee that all new appliances be carefully investigated by each utility company, and if considered satisfactory, that they should be given as much prominence in their advertising as possible in order to create and perhaps advance the market.

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## *Creating Customer Acceptance For Domestic Ironing Machines**

*In accordance with the decision to confine the activities of the motor driven appliance committee this year to one appliance, the ironing machine was chosen for consideration. A co-operative plan for an ironer campaign has been outlined by this committee and has been adopted by one of the member companies for its fall program.*

THE motor driven appliance committee of the Commercial Section decided at the beginning of the year:

1. To pick one appliance this year for study.
2. To try to do something tangible even though it might be relatively small.

### IRONING MACHINE SELECTED

After considering all appliances, the ironing machine was selected as the appliance needing the most attention from the marketing standpoint and the following was taken as an objective—to do something to "Create consumer acceptance for domestic ironing machines."

The adoption of this objective was based on the following:

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* Report of the motor driven appliance committee, merchandising bureau, Commercial Section. G. B. Schuyler, chairman. W. A. Cyr, vice-chairman. R. W. Downing, Frank Ford, H. C. Goldrick, Phil Gough, R. E. Kortepeter, Robert McDonald, Myron McNeal, B. W. Reynolds, E. O. Thomas.

1. The public is at least partially sold on cleaners and washers, there being over 35 per cent saturation on washers.

2. The present sales outlets for washers and cleaners are doing at least a partial job, as there is consumer acceptance, proved by the volume of sales through the department stores and other outlets where specialty selling methods are not used.

3. On ironers the national saturation is 3 per cent. There is a tremendous potential market for this appliance, with resulting profit to the manufacturers and dealers, and with a substantial increase in the best kind of load for the utility, it being off peak and in the higher brackets.

4. The present sales outlets and methods are entirely inadequate to sell these items in sufficient quantities, even though practically all dealers offer them for sale, for the reason that the consumer is not yet sold on this appliance.

### Story Told by Skit

It was further pointed out that the electric industry itself was not (*a*) "ironer conscious," that (*b*) there was not an appreciation of the potential market and so far, (*c*) no concrete plan to better the situation. To endeavor to point out to the industry these three facts and suggest some plan, a skit was selected as the best means of illustrating the situation.

The skit entitled, "No Tickee, No Washee," written by Wm. A. Cyr, was presented to the Commercial Section at the Los Angeles conclave. At this meeting the following marketing facts were brought out in regard to ironing machines:

1. One of the greatest fields for electric appliance sales today is the ironing machine.

2. The present saturation nationally is 3 per cent.

3. In southern California alone there are approximately 175,000 washing machines in use today, all paid for, which are being used regularly, selling 175,000 housewives on the value of electric labor saving appliances in the home. This solves but one-half of the weekly laundry problem—the washing. The other half, the ironing, represents a virgin field, as only 15,000 of these homes now have ironing machines. As a labor saver the ironer equals the washer.

*Every washer buyer should be sold the washer and ironer combination at the time of washer purchase or before the washer contract pays out.*

4. A recent survey was made by the Doherty properties to determine the average consumption of current by ironing machines as compared with the flat iron, and it was found that the flat iron gave to the power company an average revenue of $6 per year while the ironing machine paid a revenue of $12 per year.

5. 160,000 homes in southern California are waiting to be served with electric ironers. This would represent an added revenue of $960,000 per year.

6. The laundry industry's growth has in recent years exceeded the washer and ironer industry's growth, largely due to the wet wash idea, although it leaves the housewife with the ironing to do. Obviously the logical market under these circumstances is the ironer, with the washer to follow; unless sold in this manner this large group will probably never be sold.

### Co-operative Marketing Plan

This meeting also brought out the following plan for a co-operative ironer campaign by power companies, manufacturers and distributors, which is intended to run consecutively in five cities, newspaper advertisements to appear in local papers for two weeks, to be followed by another two weeks of sales follow up before starting in on the next city:

*Dealers' Co-operation—*

Floor displays and window displays of ironers in power company sales rooms.

Ironers consigned by distributors.

Distributors will maintain a girl at all times on power company floor.

Distributors will arrange for advertising campaign, drawing up ads, placing copy, and attending to billing and all other details.

Distributors will maintain special ironing machine men in each territory during life of the campaign and for one or two weeks thereafter.

Department stores and dealers will be contacted for newspaper ads, window displays, radio announcements, and other publicity.

Each department store and large dealer will have a special ironer demonstrator during campaign.

Distributors will arrange for payment of tips on all ironers sold as a result of power company employees' prospects.

Distributors will address all power company retail salesmen at the beginning of the campaign in each town.

Special discount to employees during campaign.

*Power Company Co-operation—*

Provide space for floor and window displays.

Co-operate in newspaper advertising.

Send notice of campaign with monthly bills to customer.

Supply window cards.

Notices of campaign on bulletin boards.

Advise employees of $1.50 tip on ironer sales.

Arrange for power company employees to purchase ironers during campaign on time payment.

The details of the actual participation of all parties to this plan was worked out and submitted to the Pacific Gas and Electric Company in San Francisco, and on February 24th a meeting of seven interested ironing machine manufacturers and distributors was held in the offices of the Pacific Gas and Electric Company. Plans were finally approved by the manufacturers, distributors and the Pacific Gas and Electric Company and August 1st was set as the starting date for this intensive ironing machine sales effort.

By the foregoing, the committee feels that some steps have been taken that have made the Commercial Section (*a*) more "ironing machine minded" and have (*b*) given them a greater appreciation of the potential market for this appliance. It believes that this intensive ironer campaign in each of 5 northern California cities, including advertising, display and direct sales effort in all stores during the same period, will serve as (*c*) some concrete plan to better the situation, and will help to create greater consumer acceptance for the ironing machine.

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## *Range Merchandising**

*As part of the report of the range committee this year is submitted the following description of the lectric cooking demonstration truck which has been used by the Southern California Edison Company with much success.*

THE Southern California Edison Company has met with considerable success in presenting the story of electric cookery to the women of this territory through the medium of our demonstration truck. It is a one-ton truck equipped with a body 9 ft. long, 6 ft. wide and 6 ft. high, inside dimensions, painted with suitable signs, announcing the nature of its work, on the side and rear end.

This truck is equipped with a 10-kw. transformer which is connected to the primary through a cable which terminates on a fuse board attached to the crossarm by means of transformer hooks. This cable is permanently connected to the transformer and is carried up through the forward end of the truck into a storage box mounted on top of the driver's cab, thence through a ring in a folding mast which is hinged at the forward end of the truck body and lies flat on top of the truck when in transit. When raised and properly guyed by means of ropes to rings on the truck frame, this 9-ft. mast, plus the height of the truck, gives us the 18-ft. clearance required by law for primary cable.

The secondary from the transformer passes through a 100-amp. switch and necessary fuses and is carried through openings on the side of the truck body, through a three-wire, heavily insulated cable to a terminal board in the room in which the demonstration is to be held. This cable is waterproof and can be laid on the ground, passed through win-

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* Written for the range committee, merchandising bureau, Commercial Section. Paul B. Wilson, San Joaquin Light & Power Corporation, chairman. C. M. Campbell, C. F. Edwards, W. S. Fleming, G. V. Footman, H. L. Garbutt, J. H. Jamison, R. W. Kimberlin, A. W. Krueger, Harry Lippert, H. C. Rice, L. D. Sherman, Louis Swenson, R. W. Turnbull.

dows, and over transoms, so that it is unnecessary to do any cutting or otherwise to mar the building.

Connections to the primary service can be made by a primary service man in a very few minutes, as soon as the truck is placed in position. The truck can be 150 ft. from

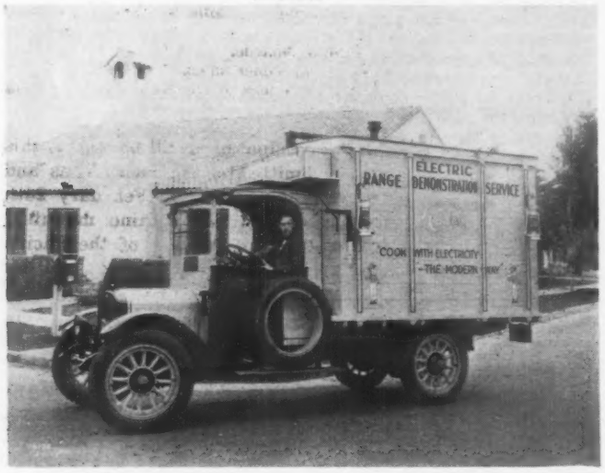


*Fig. 1. Exterior of range demonstration truck used by the Southern California Edison Company Ltd. The oil lanterns on the side of the truck are required by law, as it is necessary for the truck to stand on the street all night at times.*

the nearest pole, without undue strain being placed upon the cable or mast.

We carry two electric ranges, 50 folding chairs, a folding table, two screens, electric water heater, box for utensils, which fits under the range, and one for food supplies on the other side, which leaves just sufficient space for the home economist's trunk. The weight is a fraction over 2,000 lb.

This truck is manned with a crew of an advance agent and the home economist. It is the duty of the former to go ahead to pick out locations for demonstrations, arrange for a suitable hall, see that invitations are issued and that newspaper notices are secured, and advise business organizations and local sales crews to bring in their prospects. The Home Economist, who is thoroughly trained, both in handling the electric range and preparing foods and in presenting the story of electric cooking in an entertaining and instructive way, makes up the other member of the crew.

Two two-day demonstrations a week are held—Monday and Tuesday, and Thursday and Friday, allowing Wednesday and Saturday to move to a new location. Each demonstration starts at two o'clock and lasts until four in the afternoon.

During 1930, approximately 167 demonstrations were given, with a total attendance of over 5,500 women, at a total cost of $4,250, which averaged 77 cents per person attending. To date, the 1931 attendance has averaged a much higher figure, and in most cases the cooking demonstrations are being sponsored by women's clubs, which have made the demonstration a part of their regular program.

## *Electric Water Heating**

*The electric water heating manual published in* 1925-1926 *has been revised, bringing it up to date.*

THE electric water heating committee for the past year has revised the water heating manual that was issued by the 1925 and 1926 committee.

It was felt by the committee that electric water heating had made wonderful strides during the past six years and that the information in the 1925 and 1926 manual had naturally become obsolete. Therefore, the committee obtained up-to-date information, which was embodied in the new manual.

The manual has been revised along the lines of a sales manual, to be used in selling electric water heating and in encouraging its use by the public.

* Report of the electric water heating committee, merchandising bureau, Commercial Section. R. C. Bragg, chairman. H. V. Mooney, vice-chairman. C. E. Allen, A. W. Elliott, H. H. Fogwell, G. V. Footman, Philip George, M. L. Hooper, J. D. Mercer, Frank Moon, M. W. Phillips, P. P. Pine, C. A. Russell, Emmett Ward, J. W. Wrenn.

## *Electric Air Heating**

*The work of this year's air heating committee was to prepare a sales manual on the subject of electric air heating, the manual to discuss the advantages of electric heating from the sales standpoint, as well as to contain engineering data and other information.*

IT was felt that there was a dire need for a sales manual on electric air heating to serve as a new business getter, as well as an engineer's handbook. Previous manuals on this subject have been devoted almost entirely to the discussion of engineering problems, very little being written from the sales standpoint.

This manual is now finished and it is not only the most complete manual ever presented by the P.C.E.A. on this subject, but it will be the most complete treatise on the subject of electric airheating ever written.

The first part of the manual is devoted entirely to the discussion of the advantages of electric heating, written in simple non-technical language, so that it may be readily understood by the layman and may sell the idea of electric heat.

The second chapter discusses the cost of operating electric heating installations of different classifications.

The third and fourth chapters are of a more technical nature, as they explain the methods of laying out heating installations, types of heaters and, generally, the fundamentals of electric heating.

The fifth and sixth chapters contain all the tables that are needed by the electric heating engineer, as well as other useful information on this subject.

This manual as written will serve to inform the layman, to educate the novice salesman, the electrical contractor, architect and others interested in the sale or installation of electric heating. It will serve as an invaluable handbook for the experienced engineer. This book, as written, will therefore serve all branches of the electrical industry.

* Report of the air heating committee, merchandising bureau, Commercial Section. E. F. Perkins, chairman. C. A. Russell, vice-chairman. L. A. Bartlett, O. S. Clifford, H. H. Daley, H. H. Douglas, W. S. Fleming, L. A. Krieg, Frank Moon, N. E. Paulson, P. P. Pine, P. H. Robinson, A. Strauch, G. E. Zelhart.

## *Commercial Cooking**

*The commercial cooking committee this year has devoted itself to increasing the sale of the N.E.L.A. manual on commercial cooking and baking. It recommends that especial attention be paid to the sales possibilities in smaller electric cooking appliances for commercial use.*

* Report of the commercial cooking committee, merchandising bureau, Commercial Section. J. W. Wrenn, chairman. A. A. Anderson, E. W. Florence, H. F. Huggins, F. L. Moon, R. McDonald, Stanley Perkins, Edwin Pierce, H. W. Sterling, C. C. Smoot, Geo. Zelhart, P. P. Pine, J. C. Hoyt, H. E. Welsh.

THE activities of this committee for the year included the increasing of the distribution and sale of the commercial cooking and baking sales manual prepared by the National Electric Light Association. Reports of activities up to the first of March show that 140 copies of this book have been sold in our geographical division, which was in excess of those disposed of by any other geographical division, with the single exception of the Eastern division, comprising New Jersey, New York, and Pennsylvania. It was considered more advisable to distribute this book than to prepare a special one of our own.

### Motion Pictures

The committee's activities were to have included the preparation of a number of films to be incorporated in a national cooking and baking film that was to be prepared by the national committee. Unfortunately, the plans of the national committee, which was to furnish the films, were changed at the last moment and this part of our activity was canceled.

### Auxiliary Electric Appliances

In its investigations, the committee has found that auxiliary electric appliances for use in commercial kitchens, such as electric toasters, coffee urns, griddles, roasting ovens and fry kettles, should receive the special attention of commercial salesmen at the present time. These smaller appliances, it is estimated, will produce a usage of from 1,500 to 2,000 kw.-hr. per year per kilowatt of connected load.

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## *Electric Refrigeration**

*The refrigeration committee this year is tying in with the national campaign. An extensive campaign is already outlined for northern California and it is anticipated that similar support will be received elsewhere, to bring the total sales up to the quota of* 60,000 *refrigerators fixed for this district.*

WE are pleased to report that every power company in California is at the present time either selling or directly promoting the sale of electric refrigeration.

The leading power companies have agreed through advertising to feature the N.E.L.A. slogan, "Invest in an electric refrigerator."

All sales promotion material for the spring campaign has been released and the co-operating power companies are now beginning its use.

Several of the power companies are instituting aggressive campaigns to sell refrigerators to their employees.

The northern California refrigerator distributors and dealers have appropriated a considerable sum of money to match that appropriated by the power company for an extensive newspaper campaign, carrying only the signature of the power company and the National Refrigeration Bureau.

Bill stickers, special refrigeration exhibits, home economics activities, truck banners and many other forms of publicity will be used, not only by power companies but by every distributor and dealer involved.

Similar plans will no doubt be employed this year throughout the entire Pacific Coast, and this committee feels certain that by December 31st a total of 60,000 new electric refrigerators will have been sold.

We recommend that some permanent plan be evolved, which will assure in future years the continued recognition of electric refrigeration as a major appliance promotion activity.

We recommend that the wiring committee and the Red Seal committee provide in their plans and in their contact with architects, builders and home owners, for the installation of a convenience outlet and a space especially provided for an electric refrigerator.

The average household electric consumption for all purposes combined, amounts to only 550 kw.-hr. per year and every refrigerator consumes about 600 kw.-hr. per year; therefore, a new electric refrigerator is equal to a new consumer.

* Report of refrigeration committee, merchandising bureau, Commercial Section, L. H. Bennett, chairman. W. J. Ashenbrenner, Oscar Clifford, O. R. Doerr, C. N. Elgan, Edwin Pierce, F. M. Rowles, Fred Salt, T. G. Supplee, Pierre Vinet.

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## *This Now Wiring**

*Four recommendations are made in the following address, covering the questions of materials, labor, wiring regulations, overhead and profit.*

UNFORTUNATELY, or fortunately, depending upon your stance as you look out over the fairways of the matter, and whether you are addicted to a hook or a slice, electricity has to be delivered over wires. Even the imagination-catching "wireless" or "radio" as it has since become, has not freed man from the need for miles and miles of wire.

If electric energy, which we are all so interested in seeing sold in increasing quantities, could be wrapped up in paper sacks, all our troubles, even including this committee, would be over. We could sell "juice" at so much a bottle or sack, and make it a cash and carry proposition. The complications of the business we are engaged in would be simplified, among other things, by the elimination of meter readers and meter readings, customers' deposits, electric transmission and distribution departments, and their superintendents, engineering departments which tell enthusiastic salesmen that it will take six poles instead of one and a half to reach a farmer's pump, work orders, linemen who dig up customers' lawns, easements for perpetual rights-of-way over someone's back lot or ranch, the right size transformers, underground service agitation, moving of poles to please influential customers in ritzy residential districts, voltage drop, stubs and guys, rate departments, maximum demands, minimums, electrical contractors, and no end of other impediments. One of our most difficult problems—that of selling average lighting customers, large newspapers and small politicians on the fact that electricity, manufactured at only a few mills per kilowatt-hour at the power plant, costs so many cents at the meter delivered—would disappear. We could take our place along Main Street in an ordinary kind of store equipped only with a ratchet wicket gate, and have assorted kilowatts on the shelves and appliances on the tables. The customers would file in through the one-way gate and pass the cashier on the way out, carrying home a week's supply of electricity and appliances. Our business would no longer be a nightmare, but a peaceful dream. Life would be simple.

Please do not regard what has just been said as facetious. It is fundamental to this entire subject of wiring. In dealing with the matter which so often tips over our equilibrium as does this controversial subject of wiring and what it should cost, we need something simple, even ridiculous, to restore our true sense of proportion.

That wire must be used is a *fact*. As with our wives, we are married to that fact and we must live with it somehow. The sooner we settle down to getting along with the fact, the fewer repressed complexes, if that's what give us sleepless nights and halitosis, we will build up for ourselves.

Very well then, if wiring is a fact, and it is, just how much and what kind do we have to have, becomes the first

* Presented as an address at the Fresno meeting by Wm. Cyr, chairman of the wiring sales committee.

real question. The answering of that question involves knowing just what wiring practice is at present, whether anything better is offered to take its place, what it costs and why it costs that much,—in fact it involves a great many more *facts*, not just opinions.

The personnel of this committee was well chosen for its purpose. As your chairman saw it, there must be enough engineers and practical men who could treat of the facts to keep the work sane and sensible. First, we must keep the P.C.E.A. from making itself petty and quarrelsome and, if you please, ignorant. Next, too, the committee must have enough commercial men to interpret the desires of the commercial departments and to set forth their needs in wiring.

Wide divergences of opinion separated the actual members of this committee when it began its work. These same divergences still exist. It has been impractical to hold committee meetings, but then such committee meetings might have degenerated into fruitless debates, in which neither affirmative nor negative were speaking on the same subject. Wiring is one of those subjects on which several people, apparently headed for the same point, can go off from in all possible directions.

Long personal interviews, deliberate, frankly outspoken, and yet by far more satisfactory in results, seemed to the chairman a better means of arriving at a complete cross-section of the problem. Thus the work of the chairman has been to listen to each of the many sides represented, absorb the viewpoint and make a record of the facts, and then to retire to the privacy of a Northwestern Pacific ferry and seek to correlate and digest these various facts and opinions into a definite recommendation of policy and a selling plan for wiring.

To this task has been brought also an extensive reading of the trade press reports and findings on this subject, plus the history of the entire wiring controversy, which since 1925 has refused to stay settled, despite some most excellent, and it was hoped each time, final reports made on the subject in inter-industry conferences. Nor has your chairman any youthful hope that this report, designed as it is to be a final and basic document, will prove any more the touchstone that turns all wiring problems into gold for central station, contractor and engineer, than has its predecessors. Tomorrow, when you go home, some salesman will come to you beaten and bleeding, discouraged and disgruntled, and blame the high cost of wiring for a poor sales job. After all, it would be a pity to rob our suffering salesman of the best, the most all-embracing, the grandest, oldest standby among all his alibis. Not even a wiring committee would be so cruel.

All this preliminary is merely to establish the soundness, the thoroughness of the method your wiring committee this year has sought to pursue in its work, and hence to establish the fairness of the conclusions it makes in this report without burdening you with every item of supporting detail. There is abundant detail, and for those who may question our conclusions this detail and data will be cheerfully submitted.

Now let us get down to some of these *facts*, spoken of so highly.

### Fact No. 1. Wiring Costs Money

This is one of those things, an axiom, such as all of us had to take for granted when we studied geometry. No need going into the philosophy of it. Wiring costs something. Whether it costs too much or not enough or just what it ought to, involves knowing what are the elements of its cost. These break down into:

Materials
Labor
Environment
Overhead
Profit

It is necessary that the fundamentals of each be considered briefly in order to understand well enough the situation, and from this understanding to evolve definite and just policies.

*Materials—*

Materials then, represent from 40 to 60 per cent of the actual production cost of wiring. Whether it be the installation of another convenience outlet, a range or an office building lighting system, this is true. It has been around this one item in the cost that the entire wiring controversy has centered. As a sizable item in the cost, this is natural. Moreover, it is the only fixed quantity of the equation—all the others are as variable as a tempermental woman.

There are two philosophies operating on the cost of materials. One school holds that what we need is new and cheaper wiring methods. The other holds that fewer and simpler methods will reduce costs more.

Please do not prejudice this discussion, even if it becomes necessary to name which group is which. You can appreciate that the two schools hardly speak to each other, because they are speaking two different languages.

Those who favor new and cheaper materials base their reasoning on improvement, invention and development. They are representatives of a group whose greatest economies in their own field have sprung from improved design. But the economies they have effected by that method have been made when, but only when, the machinery improved upon by the new has been scrapped. So far, this group has met stubborn opposition to the introduction of newer and cheaper methods, such as non-metallic sheathed cable, armored flexible cable, thin wall tubing, bare neutral wiring, armored service entrance cable, even concentric wiring. From intimate observation of the causes for this opposition, this recommendation of policy is set down.

1. *For every new improved wiring method proposed, once it has been tested thoroughly and approved, let there be a concentrated effort to remove from the market as soon as possible the wiring method it supplants. Only by scrapping the out-worn will true economy be reached.*

This committee is not yet prepared to pass judgment on any of the new wiring methods proposed. It has gathered much data, but it would be the height of impertinence for it, as ignorant as it still is, to say definitely, for instance, that the material introduced as Romex, non-metallic sheathed cable, is superior to knob and tube. The chairman may have his personal opinion, but he has never wired a house.

What this committee does recommend is that (1) the subject be really studied by our engineers, (2) that company properties be used as testing grounds for these new wiring methods, (3) that the facts be gathered and compiled.

Let the light and power group in the industry, upon the demand of its commercial departments, urge upon its engineering department as its only group competent to judge, the study of the advisability of "replacing," (please take that word in its complete sense), of replacing knob and tube wiring with (1) non-metallic sheathed cable, (2) concentric armored cable, (3) flexible metallic cable. Let it study the advisability of completely substituting heavy pipe with the thin wall conduit, at least in the smaller sizes. Let it study carefully and gather actual test data on bare neutral wiring, let it make inductance tests, interference tests, test of straying currents. So far, most of the discussion of these subjects has been theoretical. Let us have some actual data.

Then with this case history in hand, let it go to the second group and support them in their main premise, simplicity, by enlisting their support, in replacing and entirely eliminating, the methods found to be inferior to the newly designed and improved methods.

For this second group, that favoring simplicity and even going so far as to legislate it in some instances, can be en-

listed by the proper approach. This group is one whose practical experience has made it desire simplicity.

It seems to your chairman that a great deal of time has been lost by the utility group in its efforts to force the inspection interests into line with its thoughts on wiring, rather than to enlist the support of wireman, contractor and inspector in the program it desires, selling them the desirable features it proposes. Salesmanship consists of presenting a subject to an opponent, or a buyer, in the light of the latter's own best advantage, even if the subject be a wiring method.

Let us examine for a moment the chief premise of this second group and see whether it can be reconciled to the new method group.

The installation group resents every attempt to complicate its already exceedingly ramified business. Harassed by ignorant and very often dishonest competition in a game which is often more gamble than business, the leaders of the contracting group wish nothing so much as simple, easy construction method. Consider a moment that there are some 400 different kinds of outlet boxes, besides all the variety of fittings, for one wiring method alone (conduit), mind you. There are whole great bulky catalogs of fittings. If you want to know why contractors resent new wiring methods, spend an evening going through the catalog of just one wiring material manufacturer. Remember as you do so that ordinary house wiring must pay the development cost, the manufacturing costs, the warehousing and distribution costs, of all of this material, much of which has only infrequent and highly special use. Many a contractor has been heard to say, "It seems to me these manufacturers must have a staff of designers sitting around who have to justify their existence by bringing out a lot of new devices and fittings every once in a while, most of which have no practical field demand back of them and many of which are totally unsuited in a practical way to the job they are intended for."

Consider that, where all of the 15 wiring methods approved by the code are in effect, the contractor must be equipped to install any of the fifteen, must stock fittings and parts for several of the fifteen, must buy and keep special tools for them, must spend time estimating them, jockeying one against the other for price advantage, must order, keep books on, inventory, and retire as obsolete many of these. He must have workmen available, skilled in any of these methods, must juggle them around to put them on the job where their skill will be useful, must understand and correctly interpret all the involved rules covering them and must try to keep sweet under the industry's constant introduction of new worries and costs.

Then consider that the jobbers must stock, inventory, keep books on, deliver, pay floor rent for, advertise, sell, catalog and all the other things jobbers do with these superfluous items. And their costs must all be paid by average wiring.

Too, the manufacturer must keep patterns, dies, machinery, stocks, must inventory, advertise, sell, catalog, ship and all the things a manufacturer does on all these items.

This year the Electragists' chapters all over the country sent to manufacturers of conduit the united request that one kind of conduit be eliminated from manufacture. "There is no sense in having both an enameled conduit and a galvanized conduit," they pointed out. The one excuse that one is cheaper than the other will disappear in the economy of concentrating on the manufacture of one product, galvanized conduit. Suppose the light and power group give support to such a program as a first step toward simplicity and economy.

The second policy recommendation this committee would make then, would be as follows:

2. *The light and power industry should lead a movement, involving the participation of manufacturer, wholesaler, contractor, dealer, inspector, and yes, even labor, to sit with the Department of Commerce and seek to reduce waste and simplify wiring materials and fittings to the least number consistent with good economics, to the end that both confusion and cost may be greatly reduced.*

There are some excellent examples of the benefits of this simplification. When Turkish towels were reduced to 6 rather than 74 grades and sizes, the industry and the public benefited greatly. We all know what standardization by the Mazda lamp companies on the inside frost lamps has done for lamp prices.

Before leaving this subject of materials, it must be said that this committee has made preliminary studies of several new wiring methods and recommends that this work be continued in an open-minded way in succeeding administrations.

*Labor—*

Labor is the first and greatest variable. Likewise, because it involves human beings, labor is the most delicate, most involved, most contradictory of the components of the wiring equation which we are striving to solve. Labor on old houses runs from as high as 80 per cent down to 40 per cent of the entire basic or prime cost of wiring.

Labor has the further unfortunate characteristic of being mulishly stubborn if it is antagonized, even as it can be brilliantly efficient if its interest and initiative are aroused. Labor, by the simple device of non-co-operation, can make itself cost out of all proportion to its worth. It can break a contractor who has guaranteed a finished price on an unknown manufacturing operation. We must understand this psychology when we consider the part labor plays in a wiring cost.

In the East, labor has often become a tyrant through its organized strength. In the West, the broken unions and demoralized labor have contributed to exceedingly low costs at the expense of quality, permanence, and skill. Neither seems to be the right answer.

The problem of labor, being one of human behavior, should be treated with some human understanding. One of the most certain elemental stimuli to produce a reaction of stubbornness and resistance is to regard labor as an inferior. Given an excuse for feeling martyred or ignored or downtrodden, any human being will break his neck to restore his self-respect (he has to live with himself twenty-four hours a day) by seeking means to turn the tables. Therefore, the understanding executive or leader is one who exalts his inferior.

If this seems beside the point, consider that it is highly desirable that this great labor variable become more stable, that its 40 to 80 per cent increment of total cost be measurably reduced. Consider, also, that the only possible means for lowering the cost of labor, without impairing that institution which we all feel is necessary to prosperity, ample buying power as a result of high wages, will be to have the voluntary and interested and initiative support of labor in the following:

1. Use of labor-saving tools and devices to speed production.
2. Motion study which will result in greater efficiency.
3. Devising and using of practical short-cuts which will speed installations.
4. Job management which will better co-ordinate the labor, to the material, to the job.

I submit that, humans being what they are, they will not be driven to make these economies, but they may be led. It will cost the electrical industry very little, it will commit it to nothing but tolerance and a helpful attitude, to recognize labor as a possible co-operator. The field men of the Pacific Coast Electrical Bureau often reported that they received much more enthusiastic support and actual sales help on the Red Seal plan from labor unions and wiremen, than from their bosses, the contractors who hired them.

Add to this, a real assistance to labor in reducing its difficulties and complications by reducing the number of wiring methods and materials to a minimum through adoption of a standardized, simplified line, and thus both morally and

physically will this factor in the wiring equation come nearer solution.

In Los Angeles, which has an "all conduit" ordinance, the efficiency of labor has been developed to an amazing degree. The best evidence of this is a quoted price of as low as $1.75 per outlet for residential wiring, all conduit. While this price is too low to provide overhead or proft, it indicates what standardization can do to improve labor efficiency.

As a policy on labor, then, suppose we set down this:

3. *Establish friendly though non-entangling alliance with labor to the end that greater efficiency will be promoted and the selling effort of this group added to the industry for better and more adequate wiring.*

Lest you have reason to doubt the efficiency of this selling effort, consider the damage that has been done to electrification by ignorant wiremen who have told builders and owners that they didn't need such and such an outlet.

The predominant negative attitude of labor to any and all advances advocated by capital can be "unsold" in no other way that I know of. If we want labor to cease being a "comic opera tyrant," as it has been called, we must accord it the dignity of the serious consideration it craves and will respect from a friend.

*Environment—*

Enviroment is a nice broad term which, like the new women's styles, covers a multitude of shins. Under this heading your committee throws in all the many conditions which affect the cost of wiring. These run all the way from inspection rules to the tinsmith.

We have ourselves recognized the potency of the inspection rules by the appointment of special committees to be nice to the Inspectors' Association. It might not be a bad idea to organize a similar committee to be nice to the contractors and the wiremen. The three are all bound up in a brotherhood of craft and mutual problems to which the utilities are becoming, as they grow bigger, more and more, strangers. Once upon a time our meter superintendent and our line superintendent belonged to the same lodge, but now they, too, are up on the fourth or fifth floor, insulated from their fellow wiremen of yesterday.

Our association has perceived the tendency of the inspector to make his own codes and pet ordinances. While many of these are gems of individuality, a little more uniformity and less originality would be appreciated by the public and industry alike.

The very sensible manner in which the minimum range wiring specifications were brought to almost universal California adoption, namely by meeting with the inspectors and eliciting their assistance in preparing this standard, points the way to the successful treatment of other wiring problems. And in those few cities where this specification is still held up, it might be well to approach the problem there in a more humble spirit, one of desiring to learn what is wrong and correcting it, even if it is said to be something wrong with us.

Uniform ordinances are devoutly to be wished. Their adoption may follow more readily this next recommendation of policy.

4. *Meet with inspectors and contractors and labor (for each plays a part) on a friendly and equal basis for the honest study of wiring needs and safeguards and in an united effort, seek code revisions or ordinance approval, looking toward uniformity, simplicity, and sensible economy.*

It will be well to remember that codes are always irreducible minimums, that they do not provide the customer even with a good job, much less convenient use of electricity. They constitute a bottle-neck for the utility's kilowatts, a dam set up against appliance sales, a sales resistance dam as high as the political one which has stopped everything but the muddy waters of the Colorado. Inspectors realize how pitifully low this minimum is. They know, too, their legal limitations in legislating the adequacy, which they know only too well the public is going to demand. Some of them in their dilemma, though they have never been thought a part of the selling force of the industry, in self-defense and because of a belief in the future of electricity which we wiring salesmen would do well to acquire, are going to their public with a message like one sent out by Chief Inspector Going, of Portland, recently. In effect, he said in a letter to all builders and architects:

"The ordinance which you have considered a standard of wiring all these years, isn't that at all. It is a very low minimum. If it is convenient use of electricty you want, adequacy must be provided. We submit you the following suggestions—."

There may be some virtue in driving our inspectors in desperation to go out and sell for us. To your committee chairman, this seems rather an indictment of the industry's own selling job.

About the tinsmith, we are in a very poor position to do very much. The tinsmith, the plumber, the concrete man, the carpenter, and the other house-wreckers constitute one of the most serious menaces of all to lower cost wiring, because of their total disregard for any caution during building operations. If you doubt the seriousness of the need for a large factor of safety, which must be built into the materials to resist damage during erection, go through a building under construction. Men of a dozen crafts swarm over the work, haul tools, pipe, heavy concrete buggies, timbers and all manner of apparatus. Conduit for wiring, to them, means nothing but an impediment, unless it serves as a handy peg to which to guy or support some of their scaffolding or equipment. Thinner insulation, thinner walled conduit, lighter boxes or less fittings can never be brought about, no matter how theoretically desirable, as long as they do not stand up to the practical hazards of a job. We are prone to consider all hazards which inspectors or contractors speak of as electrical. Most of them are mechanical.

*Overhead and Profit—*

"What is the use of talking about overhead?," a contractor would say. "Nobody figures it." And yet if there is to be peace in the family and every member of it selling wiring, it would seem to require that an installing contractor should be able to make both overhead and profit from his work.

Without going into detail as to what constitutes overhead, (suffice to say there are twenty-three items listed in the standard accounting system for contractors), studies of these costs conducted both by private contracting firms, and by a survey of several thousand contractors' businesses by the Electragists, show that the overhead on wiring runs as high as 47.85 per cent of the cost price of wiring, or 31.58 per cent of selling price. Scarcely any contractor can get his overhead below 20 per cent of selling price, or 28 per cent of cost, even on larger operations, and even if he maintains no store, no stock, or any of the things which may be classed as superfluous. If he is honest with himself or has proper accounting to tell him, his overhead will be around 30 per cent or more, whether his business is $25,000 a year, conducted from his garage, or $300,000 a year, conducted from an office.

Now, light and power companies have overhead, too, as hearings before utility commissions bring out. Also they desire an honest profit. Manufacturers have overhead, jobbers have overhead, not a minor part of which perhaps is in bad accounts—contractors who never should have been set up in business. All of these groups have overhead and take care of it in their costs. Theirs are easier to figure, because their type of operation is not as hazardous as a contractor's. It is only right that the industry accord the poor relation a like consideration. The same goes for a fair and reasonable profit.

Shall we define a policy as follows which will cover the two points:

5. *The installing contractor is entitled to an overhead cost and a reasonable profit, and negotiations for the purpose of establishing wiring installation prices should give due recognition to these.*

This part of our subject really deserves much more discussion than it is possible to give in this report. While it would seem to have no ramifications, yet around these two items, overhead and profit, the complaint that "the contractor is a poor salesman" is basically rooted. Some day the light and power group, the manufacturers' group, the wholesalers' group, will be able to look below the surface of the muddy waters and see that some of their own experiments in distribution are perhaps stirring up the pond, of which the contractors are but the ripples on the top. Some day, it must be recognized that the contractor who will help sell wiring and rewiring will do so because it is good business, because it is profitable to do so.

This sounds very much as though your chairman were a contractor talking, but in the position in which he finds himself, this observation comes as a result of contact with, and investigation of, each of the four branches of the industry, and a belief that any enterprise is healthy only as long as it is profitable.

Very well, we arrive now at a place where some conclusions are necessary. The possible lines of action for reducing wiring costs have been reviewed. Each one promises a slight improvement. If they are totaled up, and we are very generous in our estimate of the total possible saving, it might be conceivable that 10 to 15 per cent could be saved in wiring by reductions in costs of materials, labor and other job costs. Even if 25 per cent could be lopped off, let us examine what it would do in an actual problem.

Suppose a range and water heater sale, installed, amounts to $375. Roughly, the items are: range $200, water heater $100, wiring $75, which you will say is high. If 25 per cent were cut from the wiring cost of $75, you would have $19 saving, which would reduce the total of $375 to $356, or only 5⅓ per cent total reduction.

Even taking a range alone at $160, wiring at $40, total $200, a 25 per cent reduction in wiring would result in only a $10 cut on $200, or a 5 per cent reduction of the total.

One of this committee's members, an engineer who has worked strenuously for some years on code and ordinance work, when he made this little calculation, leaned back in his chair and asked, "Aren't we making fools of ourselves over a little thing like 5 per cent total reduction and expecting even all of that reduction to come out of only one, and a minor item of cost? If it is true that ranges aren't being sold because of high cost, why should we expect wiring to stand all of the brunt of reduction?"

Thus we return to our fundamental fact, No. 1.—"Wiring costs something." Our path leads us back to the beginning of a vicious circle. Wiring costs something. Not much can be done about it. It is a fact we must live with and learn to like. Yet, wiring is desirable, because over it electricity must be sold. What are we to do to get more of it installed? What are we to do to get old places rewired?

Well, we might try selling it.

There are a number of "shenanigans," as Spike Kenyon would term them, whereby at the present time some are striving more or less to evade facing this ugly fact. These include "free wiring," which is far from free; "portable range wiring," which is designed to be permanent; capitalizing the wiring, which involves some nice legal points and some public policy considerations as to ultimate reaction.

If you quarrel with this viewpoint, remember that this is called a wiring "sales" committee. There are other committees wooing these other enticing possibilities. We hope they make them, for a good deal of argument may be saved.

If the industry is to sell wiring, how must it do so, admitting that it is too bad that wiring doesn't show. You can sell anything that shows. If we could doll up wire in chrome finish, put it in colored glass conduit in decorative designs, then we might run it on the outside rather than on the inside walls and make lots of money. But to sell something that is black, is inclosed in an ordinary looking galvanized pipe, is buried under plaster or concrete, is tough. The auto dealer does not sell his cars on specifications or by the ugly black engine under the hood. He sells them because they have a chromium plated fly catcher in front of the radiator.

Contractors find it very easy to sell gold plated switch plates where it is impossible to sell a range service or Red Seal standards.

Wiring must be sold like Crane sells water pipe and fittings,—through the showy bathtubs, wash stands and showers. In residential wiring, this "built in" appliance idea, which is reported from the East, has all the earmarks of a real idea. Considering the breed of cats that speculative builders are, this seems to be the long-looked-for "sesame" which will open up the treasure house of Ali Babi and the Forty Thieves.

Casting about for a definite program to submit to this association for selling wiring, this committee has been able to find nothing that is so sensible or so sound as our good old college chum, the Red Seal plan. Really, we ought to do something about it.

Its companion, Red Seal commercial specifications, fits our needs for the office and building class of installation.

When the N.E.L.A. industrial wiring plan is out, we should use it too.

In concluding this very lengthy report, this committee makes one final recommendation of policy.

6. *Let us "sell" wiring. If it will not sell on specifications, let it be sold as the necessary adjunct to something that is very desirable.*

Now that seems silly, but perhaps in two things which have been called to our attention, even since arrival in Fresno, there is some index of how wiring can be sold.

The first is a calm statement from a once brilliant electric salesman of Sacramento, Monty Pfyl, now equally hot salesmanager of gas in Fresno, that "every new house being built in Fresno, costing over $4,000 is being equipped with a gas furnace."

Is every house being equipped with an electric range outlet? Why shouldn't it be? People do not put in gas furnaces for the fun of it. Somebody has convinced every individual builder that it has to be there. It can be sold.

There is a new school at Tranquility. The electrical part of that building runs up to over 10 per cent of the total cost of the building. One hears a good deal of wailing that wiring and fixtures get only 3 per cent of the cost of a building. Whose fault is that?

Down the street in Fresno there was an old lodge building. The trustees had been hoarding up money for a new building for years. They were sold the idea of using their fund on a complete job of remodeling for which they could pay cash, without added burden on the membership. They were convinced. The job is just being finished. The lodge members don't realize it, but out of their remodeling job the electrical portion is 20 per cent of the total. Electricity has given an entirely modern equipment and atmosphere to a building which otherwise would have been a derelict.

Here, then, is the crux of the wiring situation. Wiring can be sold. But, as pointed out in the foregoing, it can best be sold by what it provides. Wiring, like plumbing, can stay in the walls. It is the mauve bathtub that sells plumbing. In the lodge hall, it was a new decorative scheme, air conditioning facilities for a good time and an up-to-minute lodge hall that brought with it switchboards, motors, pipe, wire, locknuts, bushings, and—kilowatts. There was no need to

fuss around about whether it should be done in non-metallic sheathed cable or thin conduit. "Put in the best." If range wiring is difficult to sell, sell it with the range. Certainly, the range is attractive enough to carry with it cost of providing it with its life.

A new point of view is sometimes all that makes an obstacle seem difficult to surmount. What wiring needs is a new point of view. Wiring, like a wife, can be a constant irritation or it can be a blessing.

But, since to deliver electricity we must still live with the fact, let us regard wiring as an opportunity, for a change. Let us teach our salemen to regard it as a future selling facility, not an obstacle, and see if this viewpoint will not prove to be a touchstone to greater sales.

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## *Radio From the Central Station Standpoint**

*Owing to the importance of radio as a revenue producer, the radio committee recommends that particular attention be given to the elimination of radio interference. In addition to the work now done by power companies on their own systems, it is suggested that manufacturers be urged to produce non-radio-interfering appliances. A close tie-in with broadcasting stations and an advertising campaign directed toward advising the customer of good programs is recommended.*

BECAUSE of the increasing importance to the central station industry of the highly desirable revenue obtained from the use of radio receiving sets in the home, it was decided to form a radio subcommittee of the merchandising bureau.

Investigation reveals the interesting fact that the revenue derived by the power companies on the Pacific Coast from the use of radio sets, which includes energy used by radio receiving sets, and also by heating, lighting and other appliances directly as a result of radio, amounts to approximately $1,390,000 per month.

Various attempts have been made to estimate the revenue received by power companies from radio sets. A check made by the Southern California Edison Company Ltd., revealed the astounding fact that it derived $1,310,000 in revenue from 177,000 radio receivers during 1928. The method of arriving at this figure is of interest.

According to the market analysis department of Radio Retailing, there were 636,000 radio receivers in California on Jan. 1, 1929. Of these, 390,000 were in southern California. The Edison Company has approximately 450,000 lighting meters, out of a total on all systems in southern California of 990,000, or 45.5 per cent. Assuming equal distribution, the company then served 177,000 radio sets as of Jan. 1, 1929. Figures compiled by the Los Angeles Examiner based on personal calls on 600 homes, showed that 304 owned radios, of which 262, or 86 per cent, were all-electric or battery operated. Thus 86 per cent of 177,000, or about 150,000 radios, were using Edison current.

The Radio and Music Trades Association of Southern California estimates that radio sets operate on an average of five hours per day. This figure was checked closely by a newspaper, which found that 295 families operated their sets an average of 5.22 hours per day per set. Due to the great variety of makes and models of sets, it is impossible to get an accurate average energy demand, but considering twenty models, including seven popular makes, the average demand was found to be 125 watts per set. Since sets in 1928 were less modern than those today, an average demand of 100 watts was used. The average rate paid by domestic customers on the Edison system is 4.8 cents per kilowatt-hour. Thus the revenue from radio per year would be 100 watts x 5 hr. x 365 days x 0.00048, or $8.75 approximately. This, multiplied by 150,000, gives the surprising figure of $1,310,000 annual revenue. This is an average of $2.90 per year for each and every one of the company's 450,000 lighting meters.

Any utility that wishes to assume radio saturation on its system to be about the same as in Southern California and the rate to be about the same, can apply a rule-of-thumb method of arriving at the revenue it derives from radio by multiplying the number of its lighting meters by $2.90. Aside from the intriguing size of this figure of $1,310,000, it has a significance that the power company cannot overlook. Radio interference is a matter of growing importance and most utilities are now co-operating fully in mitigating this evil. Considering the large amount of revenue derived from radio receivers, the power companies are well justified in spending a small part of the revenue in promoting better public relations through interference elimination, even if it is as little as one per cent.

Because radio is highly desirable as an accessory to load building, we feel that this should be made a permanent subcommittee of the merchandising bureau, N.E.L.A.

The radio committee recognizes the excellent work being done by the power companies in helping to correct interference troubles, especially those originating in the homes of consumers, through the use of appliances that are so designed as to make it impossible to use them without causing radio interference. In this connection, the radio committee recommends that the power companies prevail upon manufacturers to see that, where possible, electrical appliances be so constructed as to minimize radio interference. An investigation has been made by the radio co-ordination committee of the Engineering Section, P.C.E.A. who finds that a great many radio complaints come from this source, necessitating the infrequent use of radio where this condition prevails. The radio committee is working closely with the co-ordination committee this year.

The radio committee recommends the second and third radio set in the home, and encourages the replacing of old and obsolete radio receiving sets with modern, up-to-date receivers in the interest of greater use. The power companies should encourage the frequent testing of tubes in existing sets, which service is generally given free by radio dealers.

It is suggested that additional information be furnished power company employees, relative to the operation and cost of current consumption of radio sets.

As the radio broadcast programs are the important factors in the more general use of radio, we think that power companies should avail themselves of the use of broadcasting for disseminating information to their customers and for building goodwill among radio set owners, who are all customers of the power companies. It has been suggested that the power companies will find it highly desirable to tell their story through broadcast programs, releasing their program after 10 p. m. at night, thereby increasing the revenue by causing the sets to be operated more hours per day. The committee believes the revenue from this source would pay the power companies many times over for the expenses incurred in the broadcasting. Also central stations can utilize their mailing lists effectively by notifying their customers of interesting broadcast programs and by working closely with publicity departments of broadcast stations.

It is recommended that the central stations, through

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* Report of radio subcommittee, merchandising bureau, Commercial Section. F. A. Mulvany, chairman. W. P. Bear, J. A. Duncan, H. C. Gerster, H. C. Goldrick, A. H. Halloran, Ernest Ingold, B. C. McDonald, A. H. Nicoll, H. E. Sherman, Jr., F. C. Todt, Pierre Vinet.

newspaper advertising, stimulate the interest of their customers in the greater use of radio by calling to their attention broadcast programs.

Radio is a necessity to the home today. Although the background is entertainment, the backbone is educational.

The central station, by assisting in creating a desire for radio reception, will be tying in with this year's slogan of "continually improve the service to our consumers."

# POWER BUREAU REPORTS[2]

## *Agricultural Power**

*The following very brief report records the fact that the chief activity of the agricultural power committee has been the revision of the agricultural power handbook.*

THE work of the agricultural power committee during the last association year has been confined to co-operative research in conjunction with the committee on the relation of electricity to agriculture and the results of its activities are indicated by revisions to the agricultural power handbook whenever new developments or research justify. During the current year four sections of the agricultural power handbook have been revised and brought down to date.

[2] R. C. McFadden, Southern California Edison Company Ltd., chairman.
Arizona Edison Company: C. T. Yates.
Central Arizona Light & Power Company: R. P. Bradford.
Coast Counties Gas & Electric Company: F. D. Beardsley.
General Electric Company: E. J. Cipperly, W. J. Delehanty, H. C. Hill, C. R. Owen, M. Rhine, A. R. Tanner.
Los Angeles Bureau of Power & Light: C. H. Dye.
Los Angeles Gas and Electric Corporation: K. H. Bennett, Jack Wells.
National Supply Company: T. J. Johnston.
Pacific Gas and Electric Company: G. W. Bernhard, C. M. Clarkson, A. M. Frost, D. H. Hickey, W. H. Park, T. A. Wood.
San Diego Consolidated Gas & Electric Company: P. P. Pine.
San Joaquin Light & Power Corporation: A. D. Church, J. R. McElroy, D. C. Scott, George Zelhart.
Sierra Pacific Power Company: O. S. Clifford.
Southern California Edison Company Ltd.: Leroy Ashley, G. N. Hawley, M. W. Phillips, C. C. Stewart.
The Southern Sierras Power Company: D. B. Wheelock.
Tucson Gas, Electric Light & Power Company: W. A. Stewart.
University of California: Prof. Ben D. Moses.
Wesix, Inc.: A. Strauch.
Westinghouse Electric & Manufacturing Company: F. E. Anderson, C. H. Brunner, J. H. Fenton, J. A. Reid.
E. A. Wilcox Company: E. A. Wilcox.

* Report of the agricultural power committee, power bureau, Commercial Section. M. W. Phillips, chairman. F. E. Anderson, F. D. Beardsley, R. P. Bradford, O. S. Clifford, W. J. Delehanty, A. M. Frost, Prof. Ben D. Moses, D. C. Scott, W. A. Stewart, D. B. Wheelock, T. A. Wood, C. T. Yates.

## *Industrial Heating**

*This committee co-operated with the Western Metal Congress, has compiled an industrial heating manual now on the press and has endeavored to promote the standardization of industrial heating appliances. Recommendations are made for future work.*

THE objectives of the industrial heating committee as approved by members of this committee for 1931 were as follows:

1. To co-operate with the National Western Metal Congress and Exposition to be held in San Francisco in February, 1931.
2. To publish an industrial electric heating manual for use of power and heating salesmen employed by the various power companies in California.
3. To prepare a standard classification of electric heating applications to be submitted to the power companies for approval.
4. To act as a clearing house for receiving descriptive data on any outstanding heating application which might be of interest to other power companies in the state.

ACCOMPLISHMENTS

The committee is pleased to submit the following accomplishments:

*Western Metal Congress—*

The Western Metal Congress and Exposition was held in San Francisco on February 16, 17, 18, 19, 20, 1931. Industrial applications for electric heat were shown and created considerable interest among manufacturing representatives. A great many high school students visited the exposition and were supplied with a list of questions which they were required to answer and submit to their instructors. The students in this way learned more regarding welding, heat treating etc. than would have been possible had they merely made a visit to the various exhibits.

*Industrial Heating Manual—*

The industrial heating manual is now in the hands of the printer and will be ready for distribution at the April meeting, in Fresno. We believe that this manual will be of considerable help to the men engaged in power and heating sales. Sufficient copies will be sent to each power company in California for their sales force. This has been the principal activity of this committee and it has been no small task to gather together the data and photographs. The chairman desires to express his appreciation for the splendid co-operation he has received from the committee members in its preparation.

*Standardization of Heating Appliances—*

This committee has not actually contacted the various power companies regarding a standardization of electric heating applications. However, it is believed that this activity is an important one and should be followed through by next year's committee. In the event that this activity is not completed by the end of this fiscal year, such a recommendation is made by this committee.

*Clearing House—*

While this committee has not been successful in promoting the idea of having the power companies send data on heating installations to the committee, we believe that this activity should be carried on by next year's committee. It is important that the industrial heating engineers of various companies be made aware of what is being accomplished in other parts of the state.

* Report of committee on industrial heating, power bureau, Commercial Section. G. W. Bernhard, chairman. K. H. Bennett, E. J. Cipperly, G. W. Hawley, C. R. Owens, P. P. Pine, T. A. Reid, Adolph Strauch, E. A. Wilcox, George Zelhart.

## *General Power**

*Owing to the fact that much of the time of the power bureau this year was put into the writing of handbooks, reports are very brief.*

DURING the past year the general power committee has collected and prepared data showing the amounts of power used in the various industries as found in this geographical region. The data have been assembled with the

* Report of general power committee, power bureau, Commercial Section. W. H. Park, chairman. Leroy Ashley, C. N. Clarkson, C. H. Dye, J. H. Fenton, D. H. Hickey, J. R. McElroy, P. P. Pine, M. Rhine, Jack Wells.

view of finding out how many kilowatt-hours are used to produce standard measurable amounts of manufactured products.

The committee this year has also started the first edition of a loose-leaf power salesmen's manual that will include certain fundamental rules and laws affecting the electrical industry and certain fundamental data covering motors and tables frequently used by the power salesmen. This loose-leaf booklet has been prepared in letter size, and it is the idea of the present committee to have additions made to this book and have the successive committees keep it up to date. This policy has been carried out during the past few years by the agricultural power committee with very successful results. The book is at present in the hands of the printer and will be ready for distribution during the June meeting.

## *Oil Field Electrification**

*The oil field electrification committee proposed study of the following subjects during the year:*

1. *The further general study and tabulation of present uses of electricity and costs, as followed by the* 1929-30 *committee, the data collected to form the basis for handbook which is in process of completion.*

2. *Investigation of results obtained by the application of direct current in the drilling of oil wells.*

3. *Investigation of rules, regulations, service policies and methods of temporary service as applied by central station utility companies serving the oil industry in California fields.*

4. *Study of individual plant generation in oil field territory.*

5. *Study of a.c. motor application to mud pumping with relation to electric oil well drilling equipment.*

6. *Survey of oil field electrification advertising. The committee recognized that the above was a very ambitious program to undertake for the year. Considerable data has been gathered, which will be included in the handbook which is in course of preparation by the committee.*

THE committee attempted to obtain results of direct-connected drilling tests which were conducted by two major oil companies during the year, but the engineers of the oil companies did not feel that the results of these tests were sufficiently satisfactory to warrant their giving out the desired information.

Much work has been done covering the use of d.c. equipment in the drilling of oil wells, and it is recommended that succeeding committees continue investigation of d.c. drilling and attempt to obtain costs on the operation of this type of equipment, as compared with cost of operating a.c. electric equipment and steam drilling equipment.

The committee investigated rules, regulations and service extension policy as applied by the Southern California Edison Company Ltd., and the San Joaquin Light and Power Corporation. It was found that while the rules vary somewhat in the amount of free line constructed to serve permanent load under the extension rules, in the main the classifications and policies of the two companies are uniform. In the matter of temporary extension rules, it was found that the rules of both companies are identical in application.

No study was made by the committee on individual plant generation in oil field territory.

Investigation is now under way covering test of alternating current motor application to mud pumping equipment. Data on test now being conducted should be available to the committee later this year.

An extensive advertising campaign was carried on by the Southern California Edison Company Ltd., in the promotion of oil field electrification.

The San Joaquin Light and Power Corporation proposes to publish an oil field electrification bulletin for distribution to the oil industry.

* Report of the oil field electrification committee, power bureau, Commercial Section. A. D. Church, chairman, J. H. Fenton, H. C. Hill, T. J. Johnston, C. C. Stewart.

# JOINT COMMITTEE REPORTS

## *Relations With Electrical Inspectors**

A SPECIAL committee was appointed by the executive committee of the Commercial Section of the Pacific Coast Electrical Association to consist of three members from the Engineering Section and three from the Commercial Section, to contact the electrical inspectors of California. The purpose of this committee was to discuss with the inspectors the common problems arising, in which the entire industry would be interested, with particular reference to the simplification of the code, and standard practice with regard to the interpretation of the National Electric Code and ordinance requirements throughout the state.

We are happy to state that fine work has been done, with not only the sympathetic but with the enthusiastic co-operation of the inspectors, and we believe the groundwork has been laid for continued progress in solving what have become serious problems.

We hope eventually to be able to have a statewide code adopted that would be accepted by all of the municipalities of the state and become operative in the counties as well. Such a statewide code would eliminate misunderstandings, simplify construction and bring a great saving in the cost of electrical work to the ultimate consumer, at the same time furthering the use of electrical apparatus and materials.

Contact with the inspectors was made through the California Section of the International Association of Electrical Inspectors, by meeting with them at their convention and by correspondence with their officers.

Satisfactory progress has been made, in discussions with the officials of the International Association of Electrical Inspectors and at convention meetings, toward ironing out some of the differences of opinion and viewpoints concerning ordinances and code requirements.

Through contacts with R. H. Manahan, first vice-president of the International Association of Electrical Inspectors, a plan has been submitted to their executive committee, and they in turn have recommended to the National Electric Light Association a plan for a nation-wide educational campaign on "Adequate Wiring."

The Inspectors Association has gone on record to the ef-

* Report of the joint committee on relations with electrical inspectors, Commercial Section. H. C. Rice, Southern California Edison Company Ltd., chairman.
Los Angeles Gas and Electric Corporation: H. B. Wells.
Pacific Gas and Electric Company: R. R. Cowles.
San Diego Consolidated Gas & Electric Company: A. E. Holloway.
Southern California Edison Company Ltd.: W. R. Frampton.

fect that wiring adequacy is not a subject for legislative action, but is one of salesmanship. Therefore, they are heartily in favor of a plan whereby the entire industry will put on a nation-wide drive through the medium of advertising, essay contests with prizes, etc., to inform the general public as to the advantages of adequate wiring. This plan might be made of interest, from the most modest domestic installation to the largest factory or office building, and would embrace all branches of the industry; all will be equally interested.

The matter has already been taken up with C. E. Greenwood, commercial director of the National Electric Light Association, who has commented most favorably on the plan. However, it will need the energetic indorsement of the Pacific Coast Electrical Association and other interested associations, if rapid progress is to be made.

# Engineering Section[1]

## ACCIDENT PREVENTION COMMITTEE REPORTS[2]

### *Selling Accident Prevention to the Management**

***The figures presented offer conclusive evidence that a reduction in losses, both to property and in personal injuries, will result from a consistently planned and executed accident prevention campaign.***

IF CONSIDERED purely from a mercenary standpoint and entirely aside from its humanitarian aspects, does accident prevention pay dividends? This is the real question the subcommittee on selling accident prevention to the management set out to answer.

In gathering data every large power company in California was contacted, but it was found that only two companies had records and costs over a sufficiently long period of time to be of any value. Of these two companies, complete cost data was secured from only one, the Los Angeles Gas and Electric Corporation. The two accompanying tables should be convincing to the management of any utility company. Table I gives much valuable data on accidents in addition to total cost. Table II is a breakdown of these costs, giving some unit costs of great interest and value. From Table I it will be seen that the average yearly cost of accidents for a three-year period prior to 1926, before safety work was begun, was $76,636. For the next three-year period under a safety program the average annual cost dropped to $41,651, or a saving of $34,985. For the first ten months of 1930, total cost of accidents had dropped to $14,406, showing the cumulative effect of accident prevention work.

The total cost of maintaining a safety department in this company is about $10,000 a year. Based on the three-year periods, with and without safety work, it will be seen that an investment of $10,000 a year produced a saving of $34,985. Does the management of any utility need further proof that accident prevention work pays dividends?

There are other factors also that should be pointed out. Various estimates place the hidden cost of accidents at four times their evident actual cost. These include the demoralizing effect upon other members of the gang and lost time of the injured himself. There can be no doubt that destruction of property has been greatly reduced by accident prevention work, probably greater in proportion than the reduction in personal injuries. Moreover, there is the saving to the employee's economic condition, saving to the public and the public relations aspect, all of which must be given their due intangible value.

It is the committee's recommendation that this subject be given further study next year.

TABLE I—Accident Chart 1924-30. Los Angeles Gas and Electric Corporation.

| | 3-year Period without Safety Work | | | 3-year Period with Safety Work | | | 10 Mos. |
|---|---|---|---|---|---|---|---|
| | 1924 | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 |
| No. of cases reporting to Dr. | 1,038 | 1,036 | 945 | 557 | 343 | 344 | 221 |
| Total lost time accidents | 518 | 489 | 416 | 286 | 189 | 169 | 96 |
| Fatalities | 4 | 2 | 5 | 7 | 1 | 2 | 1 |
| Days lost account of accident | 19,908 | 22,232 | 14,155 | 4,325 | 10,336 | 3,059 | 1,626 |
| Serious accidents causing lost time of fourteen days or more | 103 | 101 | 72 | 66 | 51 | 35 | 22 |
| Ratio lost time accidents to employees | 1-7 | 1-7 | 1-8 | 1-12 | 1-16 | 1-17 | 1-33 |
| Lost time accidents per 100 employees | 13.3 | 12.6 | 12.0 | 7.9 | 6.0 | 5.5 | 3.0 |
| Days lost per 1,000 days worked | 17.1 | 18.9 | 14.0 | 4.0 | 10.9 | 3.4 | 0.1 |
| Average time lost per lost time accident | 38.4 | 45.4 | 32.5 | 22.1 | 54.6 | 18.1 | 16.9 |
| Average number employees | 3,819 | 3,861 | 3,446 | 3,576 | 3,105 | 3,053 | 3,195 |
| Medical and compensation costs | $79,879 | $89,645 | $60,386 | $63,564 | $30,152 | $31,238 | $14,406 |
| Average cost for 3-year period | | $76,636 | | | $41,651 | | |

TABLE II—Cost Chart 1924-30. Los Angeles Gas and Electric Corporation.

| | Prior to Active Safety Work | | | After Present Safety Work Began | | | 10 Mos. |
|---|---|---|---|---|---|---|---|
| | 1924 | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 |
| Compensation cost | $50,943 | $51,552 | $39,175 | $46,947 | $17,327 | $18,129 | $9,076 |
| Hospital cost | 8,984 | 18,792 | 6,190 | 6,009 | 5,023 | 5,475 | 2,114 |
| Medical | 19,948 | 19,308 | 14,905 | 10,606 | 7,801 | 7,544 | 3,216 |
| Total cost | 79,875 | 89,652 | 60,270 | 63,562 | 30,151 | 31,148 | 14,406 |
| Cost per accident | 76.95 | 86.50 | 63.77 | 114.11 | 87.90 | 90.54 | 60.66 |
| Accident cost per each employee | 20.91 | 23.21 | 17.49 | 17.77 | 9.71 | 10.20 | 4.50 |
| Average cost per accident over a period of six years, prior to 1930 | | | | | | | $83.19 |
| Cost for 1930 | | | | | | | 60.66 |
| Cost of accident per person employed, average of 6 years prior to 1930 | | | | | | | 16.54 |
| Cost for 1930 | | | | | | | 4.50 |

[1] Executive committee—R. H. Halpenny, chairman. H. H. Buell, vice-chairman, J. C. Abel, K. B. Ayres, A. W. Copley, R. R. Cowles, J. H. Cunningham, F. E. Dellinger, W. R. Frampton, J. C. Gaylord, F. R. George, H. S. Lane, R. P. Lutzi, H. S. Markey, H. H. Minor, F. G. Philo, J. R. Rowe, H. L. Sampson.

[2] S. C. Dickinson, Pacific Gas and Electric Company, chairman. W. E. Richmond, San Diego Consolidated Gas & Electric Company, vice-chairman.
Electrical World: Walter C. Heston.
Los Angeles Bureau of Power & Light: W. L. Smith.
Los Angeles Gas and Electric Corporation: J. R. Rowe, Vernon Taylor.
Pacific Gas and Electric Company: C. A. Jordan, S. G. Olson.
San Joaquin Light & Power Corporation: J. M. Buswell.
Southern California Edison Company Ltd.: D. G. Macey, Howard Miller.
The Southern Sierras Power Company: J. S. Allan, M. S. Slaughter.
Westinghouse Electric & Manufacturing Company: David Hall.

* Report of subcommittee on selling accident prevention to the management, accident prevention committee, Engineering Section. W. C. Heston, chairman.

# *Discipline—What Effect Has It on Reducing Accidents?**

*The subcommittee appointed by the chairman to study and report on the subject of "Discipline—What Effect has it on Reducing Accidents?" has endeavored to avoid expressing its opinion, or making recommendations, realizing that member companies may be likened to families whose problems are the same but whose methods of combating them are different. It was deemed best merely to study the policies of other companies and ascertain the opinions of executives. Several employers were interviewed and correspondence held with others and their views are summarized in this report.*

THE attitude taken by one executive is that "discipline is a necessity but should not be exercised until educational work on a large scale has been organized to train men in safe methods and make them self-reliant. However, if a man appears to be chronically careless he should be discharged. When disciplinary measures are resorted to it should be left in the hands of the department head to decide on the penalty."

Another opinion is that "discipline is not only important, but it is necessary in accident prevention work. Men who violate safety rules, foremen or others in supervisory positions who have failed to instruct men properly in safety methods or who knowingly allow unsafe practices to be followed should be disciplined."

### Other Opinions

Says one employer, "When a man is employed we should feel that our responsibility is not only to the man but to his family or dependents and that any disciplinary measures taken should not be considered 'hard boiled,' but as merciful."

Another feeling on this subject is that "in our industry as a whole discipline is too laxly established and enforced. Rules must be published defining the measures and practices that are established and which have to be observed. Too much discipline, however, will result in employees endeavoring to cover up accidents and not report them, and each organization has to decide when it has reached the point of 'too much.' No penalties, or rules not enforced, also promote the tendency to cover up accidents and encourage carelessness.

"Records should be kept of all accidents which do not involve personal injuries as this will keep employees aware of the fact that they are being continually watched.

"The deciding on disciplinary measures and the application of such measures should be handled by one department which will eliminate the possibility of a display of favoritism."

Another opinion is that "the large percentage of accidents is due to the lack of proper supervision combined with proper discipline. In the majority of cases discipline should take the form of a lay-off or discharge; a man will do more thinking and be more impressed when his earnings are curtailed. If an accident results in damage to consumer's property the person responsible should pay for the damages.

"Safety rules should be published and employees made to realize that they are to be observed. The discharging of a man is the most effective way of impressing upon others that the company is insistant on the observance of the rules and the news that a man has been discharged spreads more quickly than that of a lay-off."

It is the opinion of another that "discipline is necessary to educate employees in safety methods but that each case of violation of safety rules should be thoroughly investigated and the penalty to be awarded should be based on the merits of the case itself. The investigating board or committee should be comprised of persons who will not be influenced by personal feelings.

"Employees who violate rules or follow unsafe practices or who allow unsafe practices to be followed which result in no personal injury should be subjected to disciplinary measures."

The following is a general summary of all the opinions:

### Adoption of Standard Practice

Disciplinary measures should not be taken against violators of safe practices until rules have been adopted showing what practices must be followed in performing different classes of work. This is necessary so that employees, especially new ones, may be impressed with the fact that the company is looking after their interests by adopting standard ways of performing work, so that they may be protected against the possibility of receiving an injury caused by some other employee who was not familiar with the method by which the work should have been done.

These rules should be published in book form and each employee whose work is governed by such rules, should be in possession of the book so that he may study it and fully absorb the contents. It is not sufficient to adopt rules and merely post them on boards for reading, for in this way employees do not have sufficient chance to become thoroughly familiar with them.

### Appropriate Penalties for Violation

In order to show forcefully that the rules have been adopted for the protection of life and property a clause should be included giving authority for the inflicting of appropriate penalties for the violation of any rule. However, it is not practicable to show the penalties, as circumstances will alter cases, and it would be unfair to inflict punishment without having first thoroughly analyzed the case to determine whether or not the employee is absolutely responsible for the violation.

All accidents, however slight the injury, should be investigated, as the seriousness of an accident is not based on the result but on the cause. In many cases accidents which are equal in seriousness may have totally different results. The result, however, should have no bearing on the disciplinary measures that are to be taken. They should be based on the cause of the accident itself.

### Importance of Discipline

To say that discipline has no effect upon accidents is to work under a false impression, for discipline, if properly administered, is the most effective way of impressing upon the employee the benefit of developing the safety habit, which, if properly developed, is the principal factor in accident prevention work.

Discipline in a large organization is essential if the "esprit de corps" is to be kept at a high standard, otherwise a feeling of laxity will prevail, which in itself is detrimental to good work. When work is undertaken in a lax manner, accidents will happen.

### Nature of Punishment

Discipline does not always mean penalizing the employee financially by discharging or laying off, but may be in the shape of publicly advertising the true facts of the case, thereby causing the employee to be humiliated in the eyes of his fellow workers. In resorting to disciplinary measures it would be an unwise social act to cause disinterested persons to suffer and before any such measures are taken, consideration should be given to the financial condition of the employee and the responsibility he owes to those dependent upon him.

The penalties to be inflicted upon violators of safety rules or who otherwise work in an unsafe manner should be de-

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* Report of subcommittee on discipline, accident prevention committee, Engineering Section. J. S. Allan, chairman. C. A. Jordan, Vernon Taylor.

cided on by a board or committee of unbiased persons who will not be influenced by personal feelings and who will decide only on the merits of the case itself. Penalties decided in this manner will eliminate all chance of favoritism, which under no consideration should be allowed to exist.

Penalties may vary and a few examples are given:

Discharging.
Laying off for a specific period without pay.
Demoting.
Allowing employee to pay for damage to company or consumers' equipment which is the result of the accident.
Humiliation.
Applying for 50 per cent reduction in compensation should injury cause loss of time in excess of seven days' waiting period.

### Danger of Too Severe Penalties

However, persons entrusted with the responsibility of making decisions should be careful not to abuse their trust by the inflicting of too severe penalties, or penalties for all too slight violations. This practice will have the opposite of the desired effect by making the employee afraid to work and assume the initiative should an emergency arise.

In other industries where accidents may result in large public liability cases involving considerable financial loss, it has been found that discipline is necessary to accomplish results and reduce accidents.

### In the Electrical Industry

The human element, through not thinking and acting "safety," is directly responsible for the large majority of accidents, but through the medium of discipline this can be overcome to a large extent and measures should be taken in all cases even though no injury is received.

Our industry, although not involving the public as much as some others, is no different as far as accident prevention is concerned, and it is the consensus of opinion of the member companies that the subject of discipline is of the utmost importance and that discipline is the best means of cutting down accidents.

# *Standard Accident Statistics**

*The following report consists of a brief review of present methods used by a number of utility companies in compiling accident statistics and recommends the adoption of a standard form to be used by all companies for purposes of comparison. The form recommended is that which is now used by various companies in reporting to the National Safety Council.*

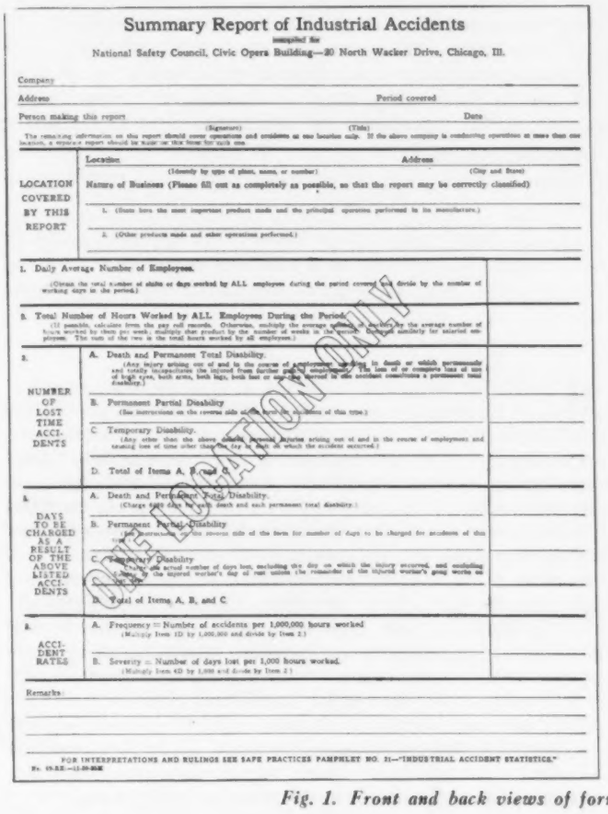
*The purpose is to enable member companies of the Pacific Coast Electrical Association to compare results on equal terms, of the extensive work being done in Accident Prevention.*

WITHIN the last decade a large number of industrial and commercial companies have adopted an entirely different method of handling the serious problem of eliminating accidents. This method, consisting of three separate steps, has proved that it is possible to reduce materially the number and severity of accidents.

The first step was to guard machinery and dangerous places by the use of approved devices and coverings; the second was that of educating the workman to use properly the tools provided for him and of giving him the necessary training to care for himself and fellow workers in the event of an accident and the third was the issuance of safety rules and the execution of rigid discipline for the violation of these rules.

To carry this work further, however, it is necessary that the various organizations engaged therein should have one common means of comparing their results. The purpose of this report is, therefore, to propose a uniform method of

* Report of subcommittee on standard accident statistics, accident prevention committee, Engineering Section. S. G. Olson, chairman, J. M. Buswell, O. G. Macey.



Summary Report of Industrial Accidents

compiled for

National Safety Council, Civic Opera Building—20 North Wacker Drive, Chicago, Ill.

Company

Address — Period covered

Person making this report — Date

(Signature) (Title)

The remaining information on this report should cover operations and accidents at one location only. If the above company is conducting operations at more than one location, a separate report should be made on this form for each one.

LOCATION COVERED BY THIS REPORT

Location (Identify by name of plant, mame, or number) — Address (City and State)

Nature of Business (Please fill out as completely as possible, so that the report may be correctly classified)

1. (State here the most important product made and the principal operation performed in its manufacture.)

2. (Other products made and other operations performed.)

1. Daily Average Number of Employees.
(Obtain the total number of shifts or days worked by ALL employees during the period covered and divide by the number of working days in the period.)

2. Total Number of Hours Worked by ALL Employees During the Period.
(If possible, calculate from the pay roll records. Otherwise, multiply the average number of employees, described by the average number of hours worked per shift per week, multiply that product by the number of weeks in the period. Disregard similarity for salaried employees. The sum of the two is the total hours worked by all employees.)

3. NUMBER OF LOST TIME ACCIDENTS

A. Death and Permanent Total Disability.
(Any injury arising out of and in the course of employment, resulting in death or which permanently and totally incapacitates the injured from further gainful employment. The loss of or complete loss of use of both eyes, both arms, both legs, both feet or any-one thereof in one accident constitutes a permanent total disability.)

B. Permanent Partial Disability
(See instructions on the reverse side of the form for classification of this type.)

C. Temporary Disability.
(Any other than the above disabling personal injuries arising out of and in the course of employment and causing loss of time other than the day or shift on which the accident occurred.)

D. Total of Items A, B, and C.

4. DAYS TO BE CHARGED AS A RESULT OF THE ABOVE LISTED ACCIDENTS

A. Death and Permanent Total Disability.
(Charge each case by each death and each permanent total disability.)

B. Permanent Partial Disability
(See instructions on the reverse side of the form for number of days to be charged for accidents of this type.)

C. Temporary Disability
(Charge the actual number of days lost, excluding the day on which the injury occurred, and excluding Sundays, by the injured worker's day of rest unless the remainder of the injured worker's group works on that day.)

D. Total of Items A, B, and C

5. ACCIDENT RATES

A. Frequency = Number of accidents per 1,000,000 hours worked
(Multiply Item 1D by 1,000,000 and divide by Item 2.)

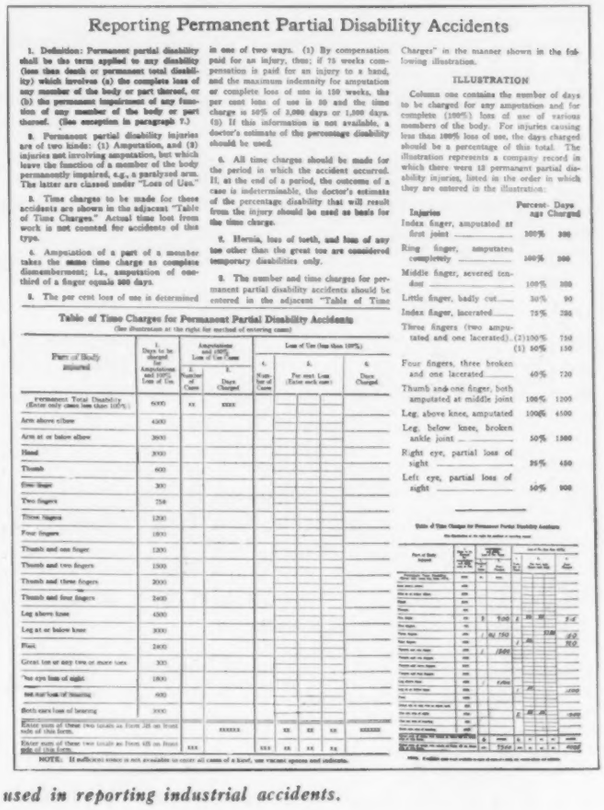
B. Severity = Number of days lost per 1,000 hours worked.
(Multiply Item 4D by 1,000 and divide by Item 2.)

Remarks:

FOR INTERPRETATIONS AND RULINGS SEE SAFE PRACTICES PAMPHLET NO. 31—"INDUSTRIAL ACCIDENT STATISTICS."

Fr. 19.32—15-30-30M

OFFICIAL USE ONLY



Reporting Permanent Partial Disability Accidents

1. Definition: Permanent partial disability shall be the term applied to any disability (less than death or permanent total disability) which involves (a) the complete loss of any member of the body or part thereof, or (b) the permanent impairment of any function of any member of the body or part thereof. (See exception in paragraph 7.)

2. Permanent partial disability injuries are of two kinds: (1) Amputation, and (2) injuries not involving amputation, but which leave the function of a member of the body permanently impaired, e.g., a paralyzed arm. The latter are classed under "Loss of Use."

3. Time charges to be made for these accidents are shown in the adjacent "Table of Time Charges." Actual time lost from work is not counted for accidents of this type.

4. Amputation of a part of a member takes the same time charge as complete dismemberment; i.e., amputation of one-third of a finger equals 300 days.

5. The per cent loss of use is determined in one of two ways. (1) By compensation paid for an injury, thus; if 75 weeks compensation is paid for an injury to a hand, and the maximum indemnity for amputation or complete loss of use is 150 weeks, the per cent loss of use is 50 and the time charge is 50% of 3,000 days or 1,500 days. (2) If this information is not available, a doctor's estimate of the percentage disability should be used.

6. All time charges should be made for the period in which the accident occurred. If, at the end of a period, the outcome of a case is indeterminable, the doctor's estimate of the percentage disability that will result from the injury should be used as basis for the time charge.

7. Hernia, loss of teeth, and loss of any toe other than the great toe are considered temporary disabilities only.

8. The number and time charges for permanent partial disability accidents should be entered in the adjacent "Table of Time Charges" in the manner shown in the following illustration.

Table of Time Charges for Permanent Partial Disability Accidents
(See illustration at the right for method of entering cases)

| Part of Body Injured | 1. Days to be charged for Amputations and 100% Loss of Use | Amputations and 100% Loss of Use Cases | | Loss of Use (less than 100%) | | | |
|---|---|---|---|---|---|---|---|
| | | 2. Number of Cases | 3. Days Charged | 4. Number of Cases | 5. Per cent Loss (Enter each case) | | 6. Days Charged |
| Permanent Total Disability (Enter only cases less than 100%) | 6000 | xx | xxxx | | | | |
| Arm above elbow | 4500 | | | | | | |
| Arm at or below elbow | 3600 | | | | | | |
| Hand | 3000 | | | | | | |
| Thumb | 600 | | | | | | |
| One finger | 300 | | | | | | |
| Two fingers | 750 | | | | | | |
| Three fingers | 1200 | | | | | | |
| Four fingers | 1800 | | | | | | |
| Thumb and one finger | 1200 | | | | | | |
| Thumb and two fingers | 1500 | | | | | | |
| Thumb and three fingers | 2000 | | | | | | |
| Thumb and four fingers | 2400 | | | | | | |
| Leg above knee | 4500 | | | | | | |
| Leg at or below knee | 3000 | | | | | | |
| Foot | 2400 | | | | | | |
| Great toe or any toe or more toes | 300 | | | | | | |
| One eye loss of sight | 1800 | | | | | | |
| One ear loss of hearing | 600 | | | | | | |
| Both ears loss of hearing | 3000 | | | | | | |
| Enter sum of these two totals on Front 3B on front side of this form. | | xxxxxx | | xx | xx | xx | xxxxxx |
| Enter sum of these two totals on Front 4B on front side of this form. | xxx | | | xxx | xx | xx | xx |

NOTE. If sufficient space is not available to enter all cases of a kind, use vacant spaces and indents.

ILLUSTRATION

Column one contains the number of days to be charged for any amputation and for complete (100%) loss of use of various members of the body. For injuries causing less than 100% loss of use, the days charged should be a percentage of this total. The illustration represents a company record in which there were 12 permanent partial disability injuries, listed in the order in which they are entered in the illustration:

| Injuries | Percentage Charged | Days Charged |
|---|---|---|
| Index finger, amputated at first joint | 100% | 300 |
| Ring finger, amputated completely | 100% | 300 |
| Middle finger, severed tendon | 100% | 300 |
| Little finger, badly cut | 30% | 90 |
| Index finger, lacerated | 75% | 225 |
| Three fingers (two amputated and one lacerated) | (2) 100% (1) 50% | 750 150 |
| Four fingers, three broken and one lacerated | 40% | 720 |
| Thumb and one finger, both amputated at middle joint | 100% | 1200 |
| Leg, above knee, amputated | 100% | 4500 |
| Leg, below knee, broken ankle joint | 50% | 1500 |
| Right eye, partial loss of sight | 25% | 450 |
| Left eye, partial loss of sight | 50% | 900 |



*Fig. 1. Front and back views of form used in reporting industrial accidents.*

computing and issuing accident statistics to be used by the various companies engaged in the gas and electric industry when reporting to the Pacific Coast Electrical Association.

After making a survey of the methods employed by a number of the utility companies, it was found that various terms or units were used. These units pertained to "frequency" and "severity" of accidents, the frequency denoted by the number of accidents in a given period of time, and the severity denoted by the amount of time lost for a given number of employees.

These figures are computed for each divisional section of the companies and for each department of the various divisional sections. The rate or standing of the section is then determined for purposes of comparison.

It was also found that a form similar to the "Summary Report of Industrial Accidents" as compiled for the National Safety Council is being used by other companies. Here the "frequency" and "severity" of accidents is denoted in a slightly different manner. The frequency is denoted by the number of accidents per million hours worked and the severity, by the number of days lost per thousand hours worked.

Other utilities have paid less attention to compiling reports, but have confined their efforts in accident prevention to a very efficient and rigid disciplinary program.

Other information required in the above mentioned National Safety Council Report, such as designating the company, authorized person making the report, period covered, nature of business, and location covered by the report, are necessary for any report covering this scope of the subject. The method used in this report form for computing the severity of an accident has, as previously stated, been adopted by a number of utilities. Therefore, it is recommended that this form be adopted by the member companies of the Pacific Coast Electrical Association.

The adoption of this form will not seriously interfere with the methods already used by individual companies in comparing their statistics within their organizations. It is thought, however, that any changes which might be made in the form will tend to increase the amount of work required in computing the necessary figures.

The actual cost of the accident to the company and to the employee has not been overlooked in treating this subject. The number of variable factors involved in computing the cost has made it necessary to exclude this very important item for this particular phase of the subject. The importance of this matter of costs warrants that it be treated more or less independently to bring out the full significance to those concerned in such matters.

A copy of the form which is recommended to be adopted is shown in Fig. 1.

# ELECTRICAL APPARATUS COMMITTEE REPORTS[1]

## *Substation Design**

*Since the last report on substation design presented in* 1927 *by a subcommittee of the electrical apparatus committee of this association, no radical changes have been made, but there has been continuous progress in a number of directions.*

*Among the more conspicuous of these developments have been: The development of outdoor equipment to the point where the necessity for a substation building has been almost eliminated; the installation of a greater number of completely automatic substations and the gradual elimination of much manual attendance; the development of factory built indoor switching equipment and apparatus tending to eliminate much of the design and construction expense of the central station company; improvements in substation installations to provide better regulation and more nearly continuous service to domestic consumers who depend more and more on electricity in their daily life; elimination of necessity for water-cooling equipment in connection with transformer installations; and the increase in number and variety of station fittings and devices made available by the manufacturers for central station use.*

*This report will discuss these subjects briefly and in order and will proceed to a running commentary on the latest design practices of the companies reporting to the committee.*

RECENT years have seen the construction of weatherproof substation equipment extend from transformers and high voltage oil circuit breakers and disconnecting switches, to rotating equipment, low voltage oil circuit breakers, induction regulators, and control and metering switchboards. Where previously a building was an essential part of every substation, investigation shows that wherever property values are not too high or considerations of appearance prevail, buildings have been minimized or entirely omitted, at a decided saving in over-all cost. The only exception to this is in large high tension substations where some building space seems to be essential, though even in these cases, there is a decided tendency toward limitation. Equipment designs have been so improved that climatic conditions do not ordinarily act as a limiting feature. Several companies state definitely that the elimination of building expense allowing them to spend more money for equipment, has enabled them to furnish better service at lower cost.

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[1] R. D. Likely, San Joaquin Light & Power Corporation, chairman. L. A. Buese, Los Angeles Gas and Electric Corporation, vice- chairman.
Allis-Chalmers Manufacturing Company: B. A. Anderson, J. L. Clark, J. G. Corrin, F. H. Searight.
Farnham & Cunningham: R. E. Cunningham.
Garland-Affolter Engineering Company: P. H. Affolter.
General Electric Company: A. Fulton, O. A. Gustafson, R. F. Monges, J. C. Porter, J. P. Price, W. C. Smith, J. F. Spease, J. S. Spurck, H. C. Stanley.
C. E. Ingalls Company: C. E. Ingalls.
Kelman Electric & Manufacturing Company: E. K. Sadler.
Los Angeles Bureau of Power & Light: J. C. Albert, H. H. Cox, C. P. Garman, O. W. Holden, Oscar Wingard.
Los Angeles Gas and Electric Corporation: G. M. Babcock, C. D. Bidwell, G. A. Riley, J. G. Rollow.
Pacific Electric Manufacturing Company: J. C. Rea, A. G. Schwager, E. F. Sixtus, Roy Wilkins.
Pacific Gas and Electric Company: W. R. Baker, C. F. Benham, S. Bowman, I. W. Collins, B. D. Dexter, R. B. Kellogg, J. M. Renfrew, A. Scott, C. W. Smith, H. T. Sutcliffe, A. J. Swank.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow, D. J. Kelly.
San Francisco Engineering Department: P. J. Ost.
San Joaquin Light & Power Corporation: E. J. Crawford, R. C. Denny, P. C. McCorkle, E. W. Otto, C. E. Schnell, D. D. Smalley.
Southern California Edison Company Ltd.: J. C. Gaylord, T. J. Lovell, R. B. Pollock, H. L. Sampson, A. P. Sessions, C. W. White.
The Southern Sierras Power Company: A. F. Ayres, M. L. Baden, F. Curtis, C. N. Parker.
H. B. Squires Company: S. P. Russell.
H. M. Thomas Company: H. M. Thomas.
U.S. Motor Company: T. G. Myers.
Westinghouse Electric & Manufacturing Company: A. W. Copley, A. R. Enger, D. Hall, R. A. Hopkins, W. P. L'Hommedieu, R. R. Richey, R. C. Stackhouse.

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* Report of substation design subcommittee, electrical apparatus committee, Engineering Section. C. E. Baugh, chairman. A. F. Ayres, K. B. Ayres, M. L. Baden, C. D. Bidwell, P. B. Garrett, T. J. Lovell, E. W. Otto, H. C. Stanley, C. W. White.

## Present Day Tendencies in Substation Design

In an endeavor to reduce rates, central station companies are continually directing their efforts toward a reduction in operating and maintenance expense. With modern equipment it becomes possible to effect a remarkable direct saving in operating expense by the elimination of manual attendance in most substations other than large transmission stations and urban distribution stations. It is of course true that the capital cost of a station is increased whenever automatic equipment is installed in place of manually operated equipment, but this extra cost is invariably found to be far less than the capitalized value of operator's wages. Certain specific cases have been found where the cost of replacing obsolete equipment in a substation has been less than the capitalized value of the reduced operating expense made possible by the change. One company in particular, in the course of rebuilding some of its older substations, has found many opportunities to reduce the number of operators from three, with a relief man three days a week, to one operator on duty 24 hours, or to do away with attendance entirely.

Thanks to the efforts of the manufacturers, it is now possible to say that there is no operation or combination of operations that can be performed by an attendant, that cannot be performed automatically. It does not follow, necessarily, that the installation of automatic equipment is always advisable. Automatic operation has been extended in practice to cover every type of substation apparatus, both stationary and rotating, and we find it in the last three years determinedly invading the field of high voltage switching for tie-lines and feeders. The Pacific Gas and Electric Company and the Coast Counties Gas and Electric Company in 1929 placed in operation a high voltage transmission substation jointly constructed and owned, to which there are connected two 100-kv. automatic reclosing supply lines fed from two external sources, four 60-kv. automatic reclosing feeders, operating in parallel with other stations, and three 22-kv. and a number of 4-kv. automatic reclosing feeders. The only attendant at this station is a patrolman living nearby. Another field for automatic high tension switching is in connection with small distribution stations with two sources of high voltage supply, in which case a system of automatic selection of the energized line or automatic transfer from a de-energized to an energized line is used. One company alone has installed six equipments of this type in the past three years.

Development of factory assembled switchgear in a variety of designs is making a radical change in the design of indoor substations. The use of steel in place of concrete enables buildings of more than one story to be made somewhat lighter, and the tedious forming and pouring of concrete for cells is eliminated, with a corresponding speeding up of the building construction program. In smaller stations, where breakers of moderate rupturing capacity can be used, control switches, relays, and meters can be mounted on a panel forming an integral part of the structure if cubicles are used, or attached to the framework supporting the equipment if other forms of switchgear are used. This construction eliminates a large portion of the control conduits and wiring associated with a detached switchboard, an item which forms an appreciable part of the cost of a small station. Another rather indirect saving comes from some reduction in overhead when factory built switchgear is purchased in place of the hundred or so odd items which must be purchased and accounted for under the other method. With skilled labor at the present prices, and with construction programs that fluctuate from year to year, central station companies cannot fail to benefit from the use of this equipment.

The extensive use of electric appliances, such as ranges, water heaters, air heaters, radios, motor driven clocks, refrigerators and a host of others, have made consumers extremely critical of voltage variations and power interruptions. We find ourselves, in the design of rural and small city substations, furnishing close voltage regulation and automatic reclosing feeder equipment in places where they would not have been considered five years ago. Here again the manufacturers have met the situation by furnishing us with automatic tap-changing equipment or small power transformers at a cost decidedly less than for induction regulators, particularly on the higher voltages, and by giving us entirely self-contained outdoor or indoor regulators which lend themselves to economical installation. Few companies would now consider building an unattended substation without providing reclosing feeder equipment. This equipment has become well standardized in the last few years and practically all circuit breaker manufacturers are prepared to furnish it.

Experience in this territory with water-cooled transformers has never been very satisfactory except at power houses where a continuous supply of fresh water is available. The maintenance and operating costs of water-cooling systems, with their pumps, piping and cooling tower or ponds are high and in a region of hard water, we find an additional expense for the installation, operation and maintenance of water-softening apparatus. This question has been answered by the installation of self-cooled transformers in the sizes up to several thousand kva., and by the development of the combination self and air-blast-cooled transformers in the larger sizes. From a study of this problem several years ago, it was found that for sizes below about 4,000 kva., it was cheaper to buy self-cooled transformers than to buy water-cooled transformers and install water-cooling and softening apparatus, even neglecting maintenance costs on this latter equipment. In passing it might be noted that the adoption of the self-cooled transformer has been one of the features that has made the unattended substation as practical as it is.

Not so many years ago most central station companies in this section maintained their own manufacturing shop, where they built a large part of the incidental station equipment used in their construction work. At the time this was not a misguided situation from an economic standpoint, because under the existing conditions it was impossible to purchase the material they needed. Necessity was the mother of a great variety of locally designed substation devices which served their purpose admirably. This situation no longer exists and it is possible to buy anything that might be required. Ordinarly any conception that central station companies can manufacture today as economically as they can buy, is false and can be explained away by saying that their costs are not correctly determined, that the equipment they build is not comparable in quality with the equipment they would buy, or that there are field construction costs connected with the assembly of home-made devices which are higher than they should be. It has been proven beyond question that the use of carefully chosen fittings particularly suitable to the work in hand and available in a wide range of prices for every need that may arise, will justify itself in sharply reduced construction costs. This is especially true on small jobs where the length of the construction period does not warrant the employment of a large construction force or the setting up of an extensive construction plant.

In passing from this portion of the report, it is only fair to note that central station companies owe an expression of appreciation to all of the manufacturers of electrical equipment for their co-operation in the solution of the problems that are continually arising in the field of substation design.

## Present Practices

In taking up the subject of present practices in substation design of the various member companies of this association, the following headings will be used:

High voltage equipment (over 20,000 volts).

Main transformer bank.

Low voltage equipment (20,000 volts and under) both indoor and outdoor.

Switchboards.
Control conduits and wiring.
Rotating equipment.
Street lighting station equipment.
Induction regulators.
Storage batteries for control.
Oil storage and handling systems for transformer and circuit breaker oil.
Station alarm and annunciator systems.
General practices.

### High Voltage Equipment

While we find a diversity of practice with respect to wiring diagrams for high voltage bus structures, it is apparent that the design of high voltage switching stations with single buses has been entirely discontinued. Two companies use main and auxiliary buses with transfer switches, though one of them states that they are tending toward the use of a double bus with selector disconnecting switches and one oil circuit breaker per circuit. One company builds only double bus structures with two breakers per circuit, and another uses this latter construction for their largest stations, with main and auxiliary buses in the majority of cases. A fifth company is practically standardized on double bus structures with selector disconnecting switches and one breaker per circuit for voltages of 220 and 110 kv., and on main and auxiliary bus structures for 60-kv. circuits.

From the standpoint of physical design the general tendency is toward the use of unit type structures for oil circuit breakers and their associated disconnecting switches and potential transformers, there being two exceptions to this. One company groups all high tension equipment on, or adjacent, to a single continuous structure, and another company follows the same practice in main and auxiliary bus construction. Most buses, with their associated selector switches, are assembled on a continuous structure, though one company reverses the procedure and mounts line dead-ends and disconnecting switches on this type of structure.

None of the companies have made use of the "fault bus" scheme of protection for outdoor bus structures, though one company has given it consideration and will possibly try it in the near future. These companies make use of one form or another of "bus differential" protection.

### Main Transformer Banks

One company is using self-cooled transformers in sizes up to 2,500 kva. and water-cooled transformers in the higher capacities, and another decides each installation on the basis of the economies of the cooling methods available. All others report that they are installing self-cooled or combination self and air blast-cooled transformers exclusively. This does not apply to hydro-electric power house installations.

Two companies state that they avoid the installation of spare single-phase transformers wherever possible by using two banks. When these companies are forced to install spare transformers, they cut transformers in and out by the use of movable taps. Another company always installs a spare transformer, one being considered sufficient for two like banks, and uses only movable taps for handling the spare. The other companies employ spare transformers in every important three-phase star-connected installation and use transfer switches or movable taps or move the spare into the proper phase position, depending entirely on the importance of the service desired from the station. Only one company has made any large number of installations for switching spare transformers without de-energizing the bank. Considerations of service have recently made it necessary for them to install a bank of four 4,000-kva. transformers, 100/11 kv., with transfer switches for energized operation, a single-pole oil circuit breaker being installed on each transformer to break charging current.

All companies are now installing permanent facilities for untanking large transformers for inspection or repair, and one company makes a practice of installing a permanent shelter for repair work in important stations where space in the substation building is not available.

### Low Tension Equipment

There is a strong tendency toward standardization of wiring diagrams for low voltage buses. All companies that have small distribution substations outside the heavy load areas are now using main and auxiliary buses, either with or without auxiliary bus tie breakers. Distribution stations in heavy load areas are being equipped with double buses with two breakers per circuit. One company states that they are tending toward a double-bus layout with selector switches and one breaker per circuit in important stations.

### Indoor Equipment

With one exception, the companies reporting state that they are in general building their own indoor switching structures, the tendency being to use steel inclosures in place of concrete. The remaining company has built no indoor switching structures in the past few years, except to match existing equipment, but has made a large number of installations of factory-assembled switch gear. The majority of the installations in the smaller stations have been of cubicle type, with the control panel forming an integral part of the structure. In the larger stations there seems to be a swing toward the elevating type of gear rather than the horizontal withdrawing truck type, though there have been a number of installations of both.

None of the companies has installed or is considering the installation of oil or gum-filled switchgear indoors. The element of cost seems to be the determining feature.

One company only is using a "fault bus" protection scheme for bus structures and extends it to include indoor transformer banks. Another company is planning a fault bus installation in connection with factory-built switch gear, but to date has had no actual experience in connection with this subject.

### Outdoor Equipment

A slight preponderance of evidence is in favor of structural steel in place of pipe for low-voltage outdoor bus structures. Apparently this can be explained by noting that the companies using pipe frameworks have designed decidedly compact structures, of a style to which pipe members are particularly adaptable. Structures which are physically larger cannot be constructed of pipe, due to its inherent structural characteristics.

All companies have taken advantage of the development of outdoor oil circuit breakers and only in exceptional cases are new installations of indoor breakers in weatherproof steel houses being made. However, only one company is consistently installing control and metering panels in housings attached to the breaker frames, while the others build detached switchboards in substation buildings.

One company has one installation of "fault bus" protection on an outdoor bus structure, and another company uses bus differential relays for protection. The other companies have had no experience along this line. The use of oil or gum-filled switchgear is not being considered for outdoor equipment any more than for indoor construction.

### Switchboards

The use of steel panels for switchboards is growing, though two companies state that they are using asbestos ebony and have made no installations of steel panels. The remaining companies that have been using asbestos have made use of steel recently and will probably continue it in the future.

Two companies report that they are buying factory assembled switchboards, and express themselves as entirely satisfied with this equipment from the standpoint of both cost and quality. A comment has been made to the effect that while some of the boards do not present quite such a pleasing appearance from the rear, they are entirely ade-

quate, and anyway, the rear of no switchboard is an object of beauty.

One company feels that miniature equipment will affect its future switchboard design materially, another that it will have no effect, a third that it can be used to advantage in special cases, and the remainder are noncommittal. There is a general impression that the fullest benefit cannot be obtained from miniature equipment, until central station companies are willing to remove relays from main switchboards to locations nearer the circuit breakers, to avoid the use of much of the control wiring necessary in present designs.

### Control Conduits and Wiring

The growing importance of this subject, expecially in large stations, is evident from a survey of the expedients adopted by various companies to minimize circuit troubles without unduly increasing costs. There is a realization that expert attention must be paid to the type of construction employed in placing quantities of control wire, running into 100 miles of single conductor in one substation alone.

The various types of construction used are as follows:

*Company A*—Lead-covered multi-conductor cable in vitrified duct, concrete tunnels, or redwood trenches, for trunk runs and in galvanized metallic conduit, with a field-placed protective wrapping for branch runs.

*Company B*—Armored multi-conductor lead-covered cable placed directly in the ground.

*Company C*—Unleaded wire in metallic conduits, or lead-covered multi-conductor cable in treated wood trenches, with metallic conduits wrapped and asphalt dipped for special cases.

*Company D*—Lead-covered multi-conductor cable in 2-in. fiber ducts for trunk runs and in machine-wrapped gas pipe for branch runs.

*Company E*—Unleaded single-conductor wire with special insulation and outside covering in 2½-in. fiber ducts for trunk runs and in wrapped gas pipe for branch runs; or lead-covered multi-conductor cable in 2½-in. fiber ducts and wrapped gas pipe or concrete-covered galvanized iron conduit. This company is planning an installation of armored lead-covered multi-conductor cable with several cables pulled into 4-in. or 5-in. iron pipes, to see if any economy can be effected.

Company A expresses itself as better satisfied with the use of lead-covered cables in vitrified ducts than with any other system that has been used in the past. Company B has used armored lead-covered cables laid directly in the earth for three years and has no complaints to make. Company E states that it has had very favorable results from the use of non-leaded wire with special insulation, and that the covering of this wire is less liable to damage in pulling into conduits than is lead-covered cable. There is a general impression that no system is satisfactory from every viewpoint and that any solution must be a compromise between economy and quality.

### Rotating Equipment

Where special equipment is necessary to provide a clean cooling medium for synchronous condensers, it appears that the favored method is the provision of a closed circulating system using air, and more recently hydrogen-cooled by water coils in the ventilating ducts. Neither air washers nor air filters have proved themselves very satisfactory, a combination of the two being required for the most effective cleaning and cooling. Two companies have had satisfactory results with condenser installations with no special provisions for modifying circulating air, and it is assumed that the location of this equipment is such that there is very little dirt present in the air.

Only one company has any considerable number of synchronous converter installations, and this company has found it necessary to provide circulating fans and filters for the ventilating air supplied to the converter room, in most cases. This construction has proven itself eminently satisfactory.

### Street Lighting Equipment

The installation of street lighting transformers and control devices is passing out of the substation picture rapidly in favor of pole-top equipment. One company is still installing primary apparatus in substations, but the remainder have entirely abandoned this practice.

### Induction Regulators

Four companies make a practice of installing bypass and disconnecting switches in connection with induction regulators, and three of them install oil circuit breakers on the exciting winding to break exciting current. One company employing a double bus with two circuit breakers per circuit, installs regulators only between one breaker and its associated disconnecting switches, and omits bypass switches. Another company in its more recent substations, equipped with 4-kv. main and auxiliary buses, has adopted the practice of omitting bypass and disconnecting switches, connecting regulator banks between the oil circuit breakers and line disconnecting switches. A similar station is now under construction in which a spare regulator bank is installed in connection with the auxiliary bus tie breaker. With these latter two connections, of course, work on the oil circuit breaker requires taking the regulators out of service and vice versa, but the necessity for a circuit breaker on the exciting winding is eliminated, in addition to the other obvious savings.

One company alone uses case grounding relays in ground regulators, and finds that they are very necessary where reclosing relays are used, inasmuch as the relay serves not only to trip the break instantaneously but to lock out the reclosing relay. The cost is negligible.

Companies that have used the new type regulators with self-contained current and potential transformers express themselves as well pleased with the simplified layouts made possible, and are especially in accord with the latest designs for outdoor installations.

### Storage Batteries

While all companies are using motor-generator sets of one design or another for the higher voltage batteries, there is some diversity of practice in the charging of small 24 and 48-volt batteries. Two companies are using bulb type rectifiers, but are trying out the copper-oxide type, while three other companies have superseded bulb rectifiers entirely with copper-oxide rectifiers. One company uses copper-oxide rectifiers on 24-volt batteries and motor-generator sets on 48-volt batteries. There is little doubt that the copper-oxide rectifiers will supersede all other types for low voltage batteries, a move justified by the low maintenance charges and extreme reliability.

For batteries of all voltages, two companies are using formed-plate type batteries, while the remainder are using pasted-plate batteries. Of these two, one company has been using both pasted-plate and formed-plate batteries until recently, when several unpleasant experiences with the former type led them to adopt the latter type almost exclusively. As a matter of fact, the use of pasted-plate batteries is economically questionable, inasmuch as the cost is more than half that of a formed-plate battery while the life is only about half under conditions favorable to the former. Under unfavorable conditions, the latter will have a life several times that of the former. Other factors involved are that the pasted-plate battery cannot be safely moved from one location to another after it has been in service a few years, nor can it be easily repaired.

### Oil Handling Systems

Practices with respect to the handling of oil in substations are very uniform, all companies installing storage tanks with permanent piping to transformers and breakers, in most of their fairly large stations.

Several companies provide a special shelter with stationary filters and pumps for handling oil in their more extensive stations, but the average installation consists of the very simplest piping layout with portable filters and pumps.

STATION ALARM AND ANNUNCIATOR SYSTEMS

Three companies make a practice of installing central alarm annunciators in their more important stations, the remainder having no equipment of this character. One company has found them of decided benefit in fairly large stations, operated by one attendant on duty 24 hours.

One company provides practically all of its unattended stations having automatic reclosing feeders or similar equipment, with a device for transmitting lockout alarm signals to a central point over telephone wires. Another company has one such installation and two more are giving serious consideration to the matter. It is apparent that we are coming to a point where it will be necessary to provide some means of informing maintenance men of outages without waiting for consumers to report them. This is only a further step in the provision of more nearly continuous service to the users of electricity located in the more sparsely settled areas.

In closing, attention should be called to the more salient points brought out by the above discussion, namely: A very definite tendency toward simplification of designs, layouts, and protective schemes; an evident desire to give the very best service possible within reason, in order that consumers shall not be disappointed in their expectations; and the broad, economically minded attitude of all engineers dealing with substation design questions.

Central station engineers should not fail to express their appreciation of the attitude of the manufacturing companies in co-operating in the solution of problems as they arise, and should take advantage of each new type of electrical apparatus with a view to their own ultimate benefit.

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## *Substation Design Practices of the Pacific Gas and Electric Company*

THE EFFECT OF GEOGRAPHY ON SUBSTATION DESIGN*

THE geography of the territory covered by an electric light and power system has a marked effect upon the type of substation required for system operation.

The territory supplied may be an urban area of dense and uniform population or it maye be a sparsely settled agricultural district.

It may be a territory containing abundant hydro-electric power, or it may be a territory where the major power must be obtained from steam.

It may be a fast growing territory, or it may be a territory whose rate of growth is very small.

A description of the Pacific Gas and Electric Company's system and the territory which it covers may serve to illustrate in what manner some of the geographical features just mentioned affect the types of substations required.

This system was born of a desire to transport the energy of falling water, easily available in the Sierra Nevada Mountains, to the power markets of the large cities, situated for the most part across the state on San Francisco Bay. Long high voltage transmission lines were constructed to connect the mountain power houses with the bay region.

These transmission lines all traverse the great central valleys of California, with their populous towns and cities and rich agricultural lands. It was the natural procedure, therefore, to build substations along the transmission lines to supply the loads offered by these growing and thriving communities. These two great valleys, the Sacramento Valley and the San Joaquin Valley, comprise an area roughly 450 miles long and 60 miles wide, which is almost completely covered by high voltage transmission lines and branch lines connected to them. There are four main high tension voltages represented: 60 kv., 110 kv., 160 kv., and 220 kv., all interconnected, and the system may be considered to form three networks, one extending from the Sacramento region north to Shasta, one, the central network, extending from Sacramento to Modesto, and one extending from Merced south to Bakersfield.

Three classes of substations are required in this territory: Substations for interconnection and switching, substations for transforming to voltages required by the distribution circuits, and substations which perform both of these functions.

It is readily seen that the distribution substations are large in number but relatively small in capacity.

They are in general connected directly to main trunk lines, but usually at some considerable distance from sources of power.

The average growth of load in this territory is about 8 per cent per year, and the load itself consists in large measure of irrigation, with a noticeable amount of domestic ranges. It is, then, highly seasonal, but at the same time continuous service is very important.

The foregoing facts lead to some very definite requirements in the design of distribution substations supplying this territory.

The large number of stations involved make economy in construction costs and in operation costs, of prime importance.

The direct connection to through trunk lines carries with it the necessity of substantial construction so that the substations shall not be a hazard to the operation of these lines.

The increase in load in this territory requires the substations to be designed so that expansion to a larger load capacity can economically be made.

All of these requirements have been given careful consideration in the design of Pacific Gas and Electric Company substations.

Economy of construction is obtained in general by standardization of component parts and by simplicity of the total layout. Advantage is taken of the impedance of the transmission circuits, to use substation transformers of low impedance, thus minimizing the cost of regulating the distribution voltage. Operating costs are made low by simplicity of design and by the use of reclosing switches.

Safe mechanical strengths and ample electrical clearances are used to minimize troubles and simple but highly satisfactory relays and connections are used to prevent troubles beyond or within substation from affecting the main transmission lines.

Economical expansion of facilities required by growth of load is provided for by generous cross-section of low tension buses and by allowing room for additional bus sections and for additional feeder switches, also by building transformer bus structures with clearances great enough to accommodate larger transformers than the original load may require.

Growth of load calls for growth in generating capacity and in transmission capacity, causing an increase in short-circuit kva. capacity at the substations. Oil circuit breakers, particularly on the high tension side of the substations, must be increased in capacity from time to time to handle properly this increasing value of short-circuit kva.

As systems grow and transmission voltages increase, the cost of oil circuit breakers increases very greatly.

The oil circuit breaker is, therefore, one item of substation equipment, whose need of replacement tends to be a maximum and serious consideration should be given to keeping

* By A. V. Joslin.

this item as small as is consistent with proper substation operation. As a means of accomplishing this purpose, the Pacific Gas and Electric Company uses only one oil circuit breaker per circuit, with two sets of air-disconnecting switches to select either one of two buses.

The large territory covered in the two great valleys and the large number of transmission lines therein also require a great many substations for interconnection and switching. These may be divided into two types: Those connected to a single high-voltage network and those for interconnection between two or more high voltages.

The former are simple switching stations without condensers or transformers and in them economy and substantial construction are prime requisites.

The latter always contain fair sized transformer banks and, as a rule, contain synchronous condenser equipment. The total number of these substations being small, economy in first cost is not so vital as it is in the case of the more numerous substations, but it is still a very desirable feature, especially in consideration of the large number of costly high-voltage oil circuit breakers required. Therefore the single oil circuit breaker per circuit scheme is used here also.

The synchronous condensers are installed with sufficient capacity to regulate the transmission voltage and correct load power factor to such an extent that synchronous correction of power factor is not required at the numerous distribution substations, thus allowing the necessary distribution voltage correction to be done more economically by induction regulators or tap changers.

The class of substations which combine the functions of both a distribution and an interconnecting station is, of course, subject to all the requirements of design that are found in each of the other classes.

In addition to the Sacramento and the San Joaquin Valleys, there are numerous smaller valleys situated among the Coast Range Mountains. While they are individually not large, they comprise in the aggregate a very large territory. They are generally long and narrow and all substations are connected to one or two trunk lines extending lengthwise of each valley. Thus they come under the same design requirement as those in the two large valleys.

The San Francisco Bay region furnishes a very large load, but except in San Francisco and Oakland, it extends in a narrow strip for about 150 miles along the shores of the bay. The configuration of the bay territory therefore causes the substations to be connected directly to main transmission trunk lines and due to the narrowness of the strip of territory, the load capacity of the substations is comparatively small. The type of substation required in this territory is therefore determined by the same requirements of economy, reliability, and ease of expansion as those in the valleys.

We may now say that the geography of the territory served by the Pacific Gas and Electric Company has caused the controlling requirements for substation design to be: Economy of construction and operation, electrical and mechanical reliability and easy and economical expansion of station capacity.

It is not hard to imagine how the major requirements of the substations operated by a system relying entirely on a few large steam plants for energy and supplying a large city and the closely adjacent territory, might vary greatly from those of the Pacific Gas and Electric Company.

In commenting on two such systems we cannot in truth say, "What is sauce for the goose is sauce for the gander," because the two appetites are very different.

In conclusion it can be said that though a substation is built for a certain definite duty, it is not an isolated unit and must therefore be designed to function correctly in correlation with the system layout as a whole and that this system layout may vary greatly in different localities and is affected in large measure by the geography of the territory in which it may be located.

## Design Features of New Equipment Installed at Newark Substation*

In order to receive at Newark substation the power developed by the Mokelumne River project it was necessary to install considerable new equipment, the most important item consisting of the 220-kv. bus and related oil circuit breakers.

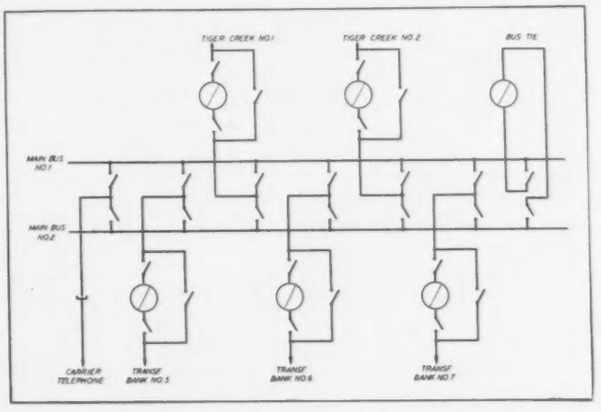


*Fig. 1. One-line diagram of 220-kv. equipment.*

The 220-kv. switching diagram shown here has been used for several years at stations of the 100-kv. and lower voltage classes, has proved to be of economical design and has met all operating requirements. It is the result of long experience with various switching schemes. A particular feature of this arrangement is that the advantage of a double bus is obtained with the use of only one oil circuit breaker for each circuit. This is a distinct economy when the cost of each oil circuit breaker is approximately $30,000.

The circuits controlled on the above bus are six in number, as follows:

Two transmission lines
Three transformer banks
One bus tie circuit.

Provision is also made for connecting carrier telephone coupling condensers to the bus. Each circuit may be connected by means of selector switches to either of the two main buses. Auxiliary signal switches are actuated by the operating mechanisms of the selector switches and give an indication by lamp signal on the switchboard of the position of each selector switch.

The 220-kv. bus structure is 354 ft. in length, 116 ft. wide and the deadend frame in the center is 64 ft. high. Each circuit bay is 46 ft. wide and supporting columns and beams are 4 ft. square. All structural members are of galvanized structural steel.

The bus conductor consists of 650,000 circ.mil hard drawn, bare copper cable concentric lay with 61 strands. The six conductors comprising the double bus are in tension and deadended on each end of the bus structure, and are supported on the cross frames with pillar type insulators at each bay. The deadend insulator strings are made up of 20 units 10 in. in diameter and are equipped with corona shields. The pillar type insulators consist of six 4-part units, 14½ in. high and 16 in. in diameter. The bus tap connections between the buses and selector switches are of the same size as the main bus and the deadend insulators are likewise the same as on the main buses. The spacing between live parts at all locations on the bus structure is 14 ft. 3 in. and from live parts to ground 8 ft.

The selector switches are vertical break and were decided upon after an exhaustive study had been made of the various

* By B. D. Dexter.

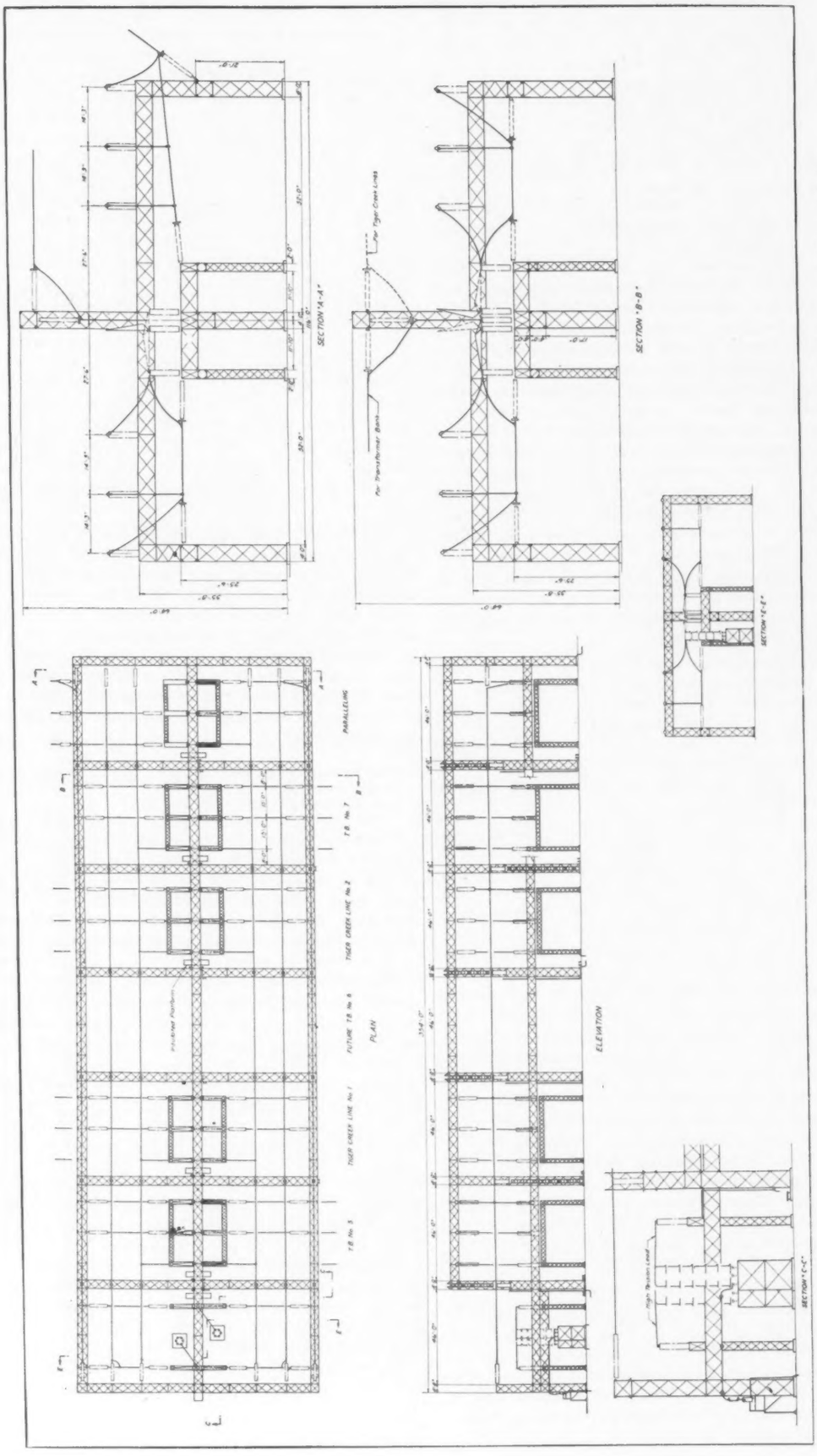


*Fig. 2. 220-kv. bus structure, with sections showing carrier current coupling at bottom, section A-A for lines, section B-B for paralleling switch.*

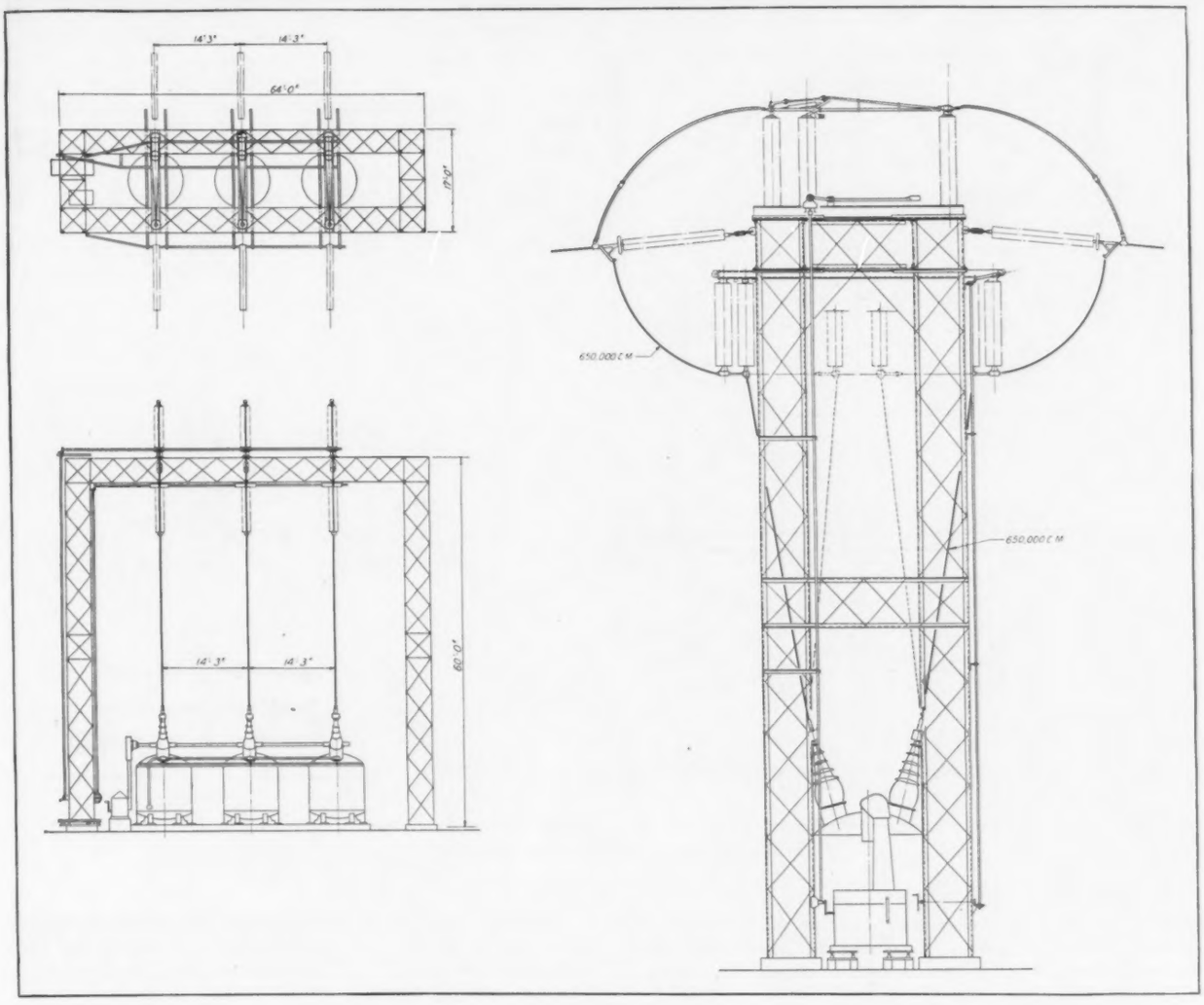


*Fig. 3. 220-kv. oil circuit breaker and disconnecting and bypass switches.*

types. A special arrangement of five insulator posts per pole was considered most suitable. Each single-pole assembly consists of two single-pole air switches mounted on a common structural steel base, with the hinged ends of the switch blades at the center of the switch and the stationary contacts at the ends of the assembly. A stationary insulator is mounted between the two movable insulators and serves to give rigidity to both moving blades and also provides a proper place for making connection to the line conductors. Connections from each main bus are made to the stationary contacts of the bus selector switches. The three poles of each selector switch are actuated by a single manually operated control handle, located at the bottom of a column adjacent to the selector switch assembly. As mentioned above, a bus section has been arranged for connecting carrier telephone coupling condensers to either bus. This section is similar to the other bus sections, except that connections are made to only two phases of each bus, instead of three, as in the case of the power circuits. The condensers are mounted on steel supports, which give proper isolation by means of elevation.

Connections from the bus structure to the oil circuit breakers are made at an elevation of 64 ft. and the center lines of the oil circuit breakers are located 98 ft. from the center of the bus structure. The two incoming 220-kv. lines and the bus tie breaker are on one side and the three transformer banks are on the opposite side.

The arrangement of a 220-kv. oil circuit breaker complete with bypass and disconnecting switches and supporting structures is shown in Fig. 3. This arrangement is similar to that employed at other 220-kv. stations of the Pacific Gas and Electric Company, with the exception of the use of a vertical break bypass switch instead of the "roller-skate" switch, which has been previously used. Inverted switches are used as disconnects. On the switch towers which control the 220-kv. lines, grounding switches are installed and are mounted on the bases of the bypass switches, grounding being effected by closing the ground switch into a contact on the center post of the bypass switch. Suitable interlocks are provided between the bypass and disconnecting switches. All switches are actuated by means of rotary shafts and are hand operated. A galvanized structural steel tower is used to support the above switch, which is 60 ft. high x 64 ft. long x 17 ft. wide.

Within the tower inclosure a six-break oil circuit breaker is mounted with the poles of the breaker on 14-ft. 2-in. centers.

As mentioned above, three transformer banks will be connected to the 220-kv. bus. The transformers are air-cooled, rated 18,000 kva., 220/110/11 kv. The 110-kv. output is

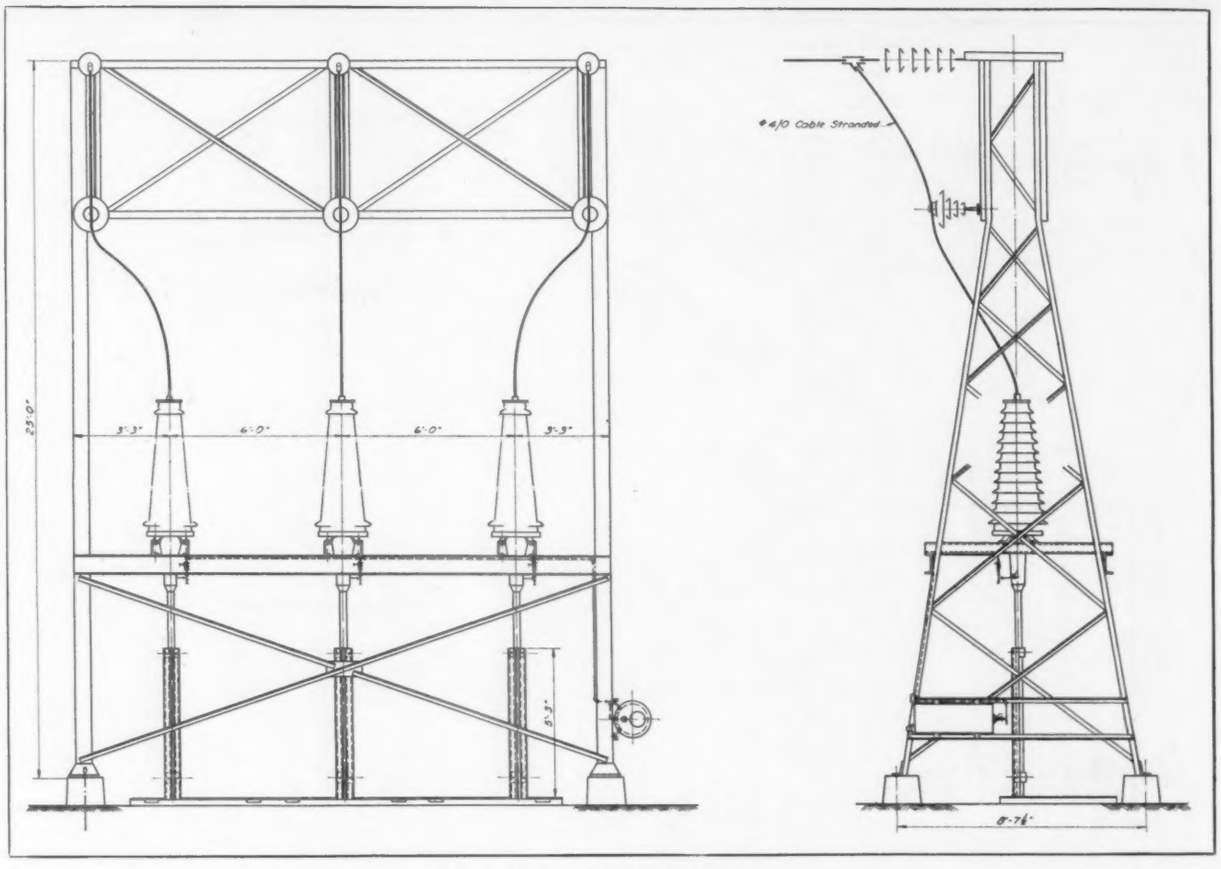


*Fig. 4. 60-kv. cable terminal mounting.*

obtained from an auto tap, and power at this voltage is delivered to the 110-kv. bus. Adjoining the transformer banks is a concrete building, which houses the 11-kv. bus and switching compartments.

These compartments, numbering fourteen, are inclosed steel construction and are completely factory built and assembled. In this structure use is made of remotely controlled motor-operated disconnecting switches as well as oil circuit breakers, a considerable saving being effected by the substitution of motor-operated disconnecting switches in place of oil circuit breakers. The oil circuit breakers are of the roll-out type, thus obviating the use of any isolating disconnecting switches.

Overhead cables form the connection between the transformer banks and this 11-kv. bus. Voltage regulation and power factor correction are obtained through use of two 25,000 kva. synchronous condensers.

Condenser starting is effected by use of one-third voltage taps connected open delta.

In connection with the installation of additional facilities at this station, it was found desirable to use reactors between section one and section two of the 100-kv. bus. This equipment consists of three single-phase air-cooled reactors rated at 5,400 kva. These reactors are installed on one bus only and are protected with bus-sectionalizing oil circuit breakers on each side.

Another item of interest at this station is the installation of several hundred feet of 60-kv. underground cable, which was necessary to avoid crossing a large number of lines with one 60-kv. circuit. The installation consists of three 500,000-circ.mil single-conductor lead and paper cables using 24/32-in. paper insulation. The cables are terminated with 115-kv. porcelain cable terminals mounted on 25-ft. steel towers.

Attention is called to the fact that due to the design of the outdoor structures described above, economies in construction were effected by the use of a caterpillar hoist. With the use of this machine all structural members were assembled and equipment put in place at a very low cost. Another feature of design affecting installation costs was the use of a ditcher in making excavations for conduits and oil pipe lines. A careful study was made in order to group, so far as possible, all ducts, conduits and pipes in such a way that the excavation costs were kept at a very low figure.

### King City Substation*

Salinas Valley, on the Pacific Gas and Electric Company system, presents a problem in substation design unique with respect to provision for expansion to meet the rapidly growing demand for power. This valley, approximately 70 miles long from the ocean to the end of the Pacific Gas and Electric Company system, is fed by two 60-kv. lines from a main transmission substation at Salinas, with a number of small 60 kv./4 kv. distribution stations located an average of five miles apart. The entire valley is being rapidly developed by irrigation from pumped water and the demands on the various substations have been increasing for several years at an average rate of approximately 10 per cent.

The irrigation load constitutes a heavy and rather constant demand throughout the late spring, summer and early fall months, and a high quality of service is necessary to avoid difficulties with the farmer consumers. Annual increases in this load over the entire valley are fairly constant, but are liable to be concentrated at any one time on one or another of the stations. Station design must provide for increasing

* By C. E. Baugh.

capacity without an undue initial expenditure, to avoid high carrying charges.

This article will describe briefly the manner in which this problem was met in a specific instance.

King City and the surrounding territory, approximately 46 miles southeast of Salinas, were supplied with electric energy until 1930 by a substation of 1,500 kva. capacity, transforming from 60 kv. and distributing at 4 kv. to the town, farms and ranches in the vicinity. In 1929 it became necessary to increase transformer capacity and as the station equipment was obsolete and inadequate, the station was entirely abandoned and a new station was constructed.

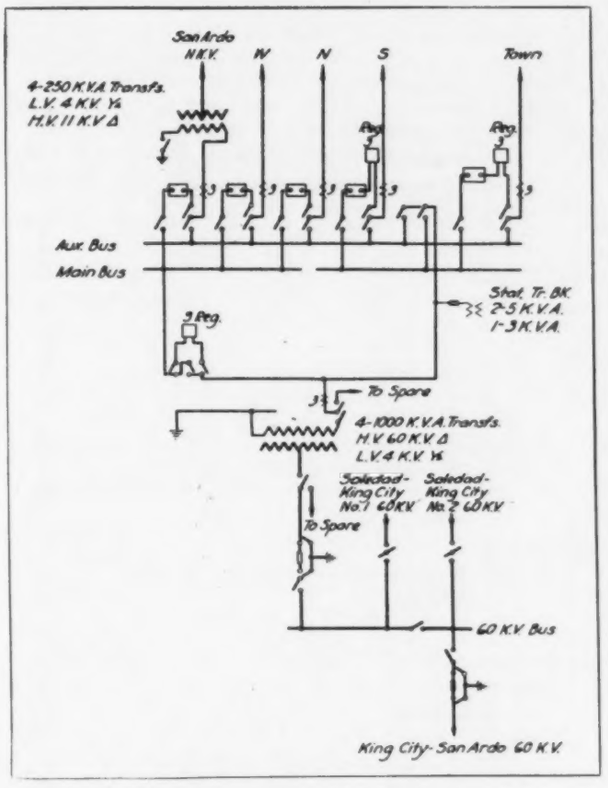


*Fig. 5. One-line diagram, King City substation.*

*High Voltage Equipment —*

Two 60-kv. lines are connected to the main 60-kv. bus through air disconnecting switches, the bus being sectionalized with an air disconnecting switch. A 60-kv. stub line to San Ardo taps off of one section of the bus, and a 3,000-kva. transformer bank is tapped off the other section. Each of these taps is equipped with a switch and fuse mounted on a standard steel structure. Under ordinary conditions the sectionalizing switch is open and one 60-kv. line feeds San Ardo, while the other line feeds the substation. This avoids the expense of oil circuit breakers and selective relays for line protection, an expenditure not normally warranted in a station of this type. Provision is made for addition of breakers on the two incoming lines if future requirements should justify them.

*Main Transformer Bank —*

The transformer bank consists of three 1,000-kva. transformers, 55,500-2,400/4,150Y volts, connected delta high side to grounded star low side, with a spare transformer. Double-throw transfer switches and transfer buses are provided on both high and low voltages for cutting in the spare transformer with a minimum of delay. This expense was felt to be justified, due to the importance of the pumping load car-

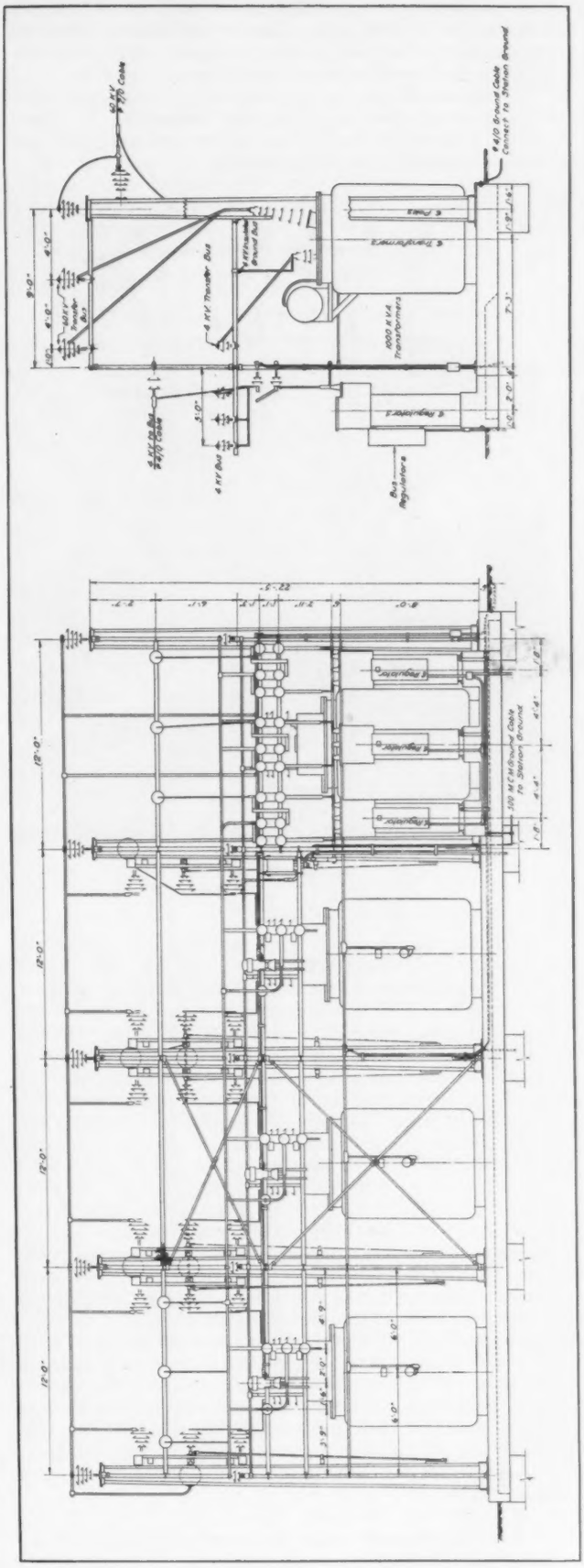

*Fig. 6. 3,000-kva. transformer bank, King City substation.*

ried from the station, which cannot be carried from any other source. The transfer switches and buses are mounted on a steel structure with latticed steel poles on the high voltage side and pipe framework on the low voltage side.

Horizontal and vertical members of the framework are of 2-in. standard iron pipe, diagonal braces are of 1½-in. standard iron pipe, and all connections are made with galvanized malleable iron clamp fittings.

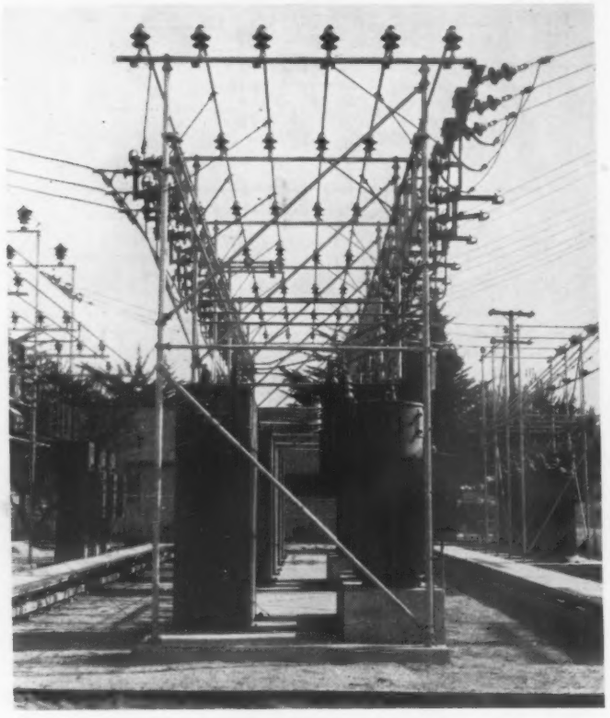

*Fig. 7. 4-kv. bus structure, end view.*

*Low Voltage Equipment —*

A six-bay bus structure with five outgoing feeders and one total bay constitutes the low voltage switching equipment. The structure is equipped with main and auxiliary buses, the main bus being divided into two portions, regulated and unregulated. The regulated bus is fed through three 200-amp. induction regulators, with disconnecting and bypass switches, and three feeders are taken from this section. Two feeders are supplied from the unregulated portion of the bus through individual 150-amp. induction regulators. The auxiliary bus is unregulated. Disconnecting switches provide for taking each breaker out of service, the feeder affected being fed from the auxiliary bus through any other breaker the operator may choose. The regulators on the individually regulated feeders are cut out by the same switching operation that cuts out the breakers. The split in the main bus may be moved along the structure, and eventually the bus regulators will be abandoned, all of the feeders being equipped with individual feeder regulators.

The structure occupies a ground area 63 ft. long x 8 ft. wide, and is built of 2-in. and 1¼-in. pipe on a concrete foundation. All pipe fittings are clamp type, the construction being identical with that described above for the transformer bank. Buses and transformer bank connections are 1-in. standard copper tubing, and all feeder connections are ½-in. standard tubing. All tubing connectors and terminals are clamp type.

Oil circuit breakers are indoor type, each inclosed in a steel housing, together with current transformers and the control and metering panel for the feeder. Each feeder is equipped with an automatic reclosing relay.

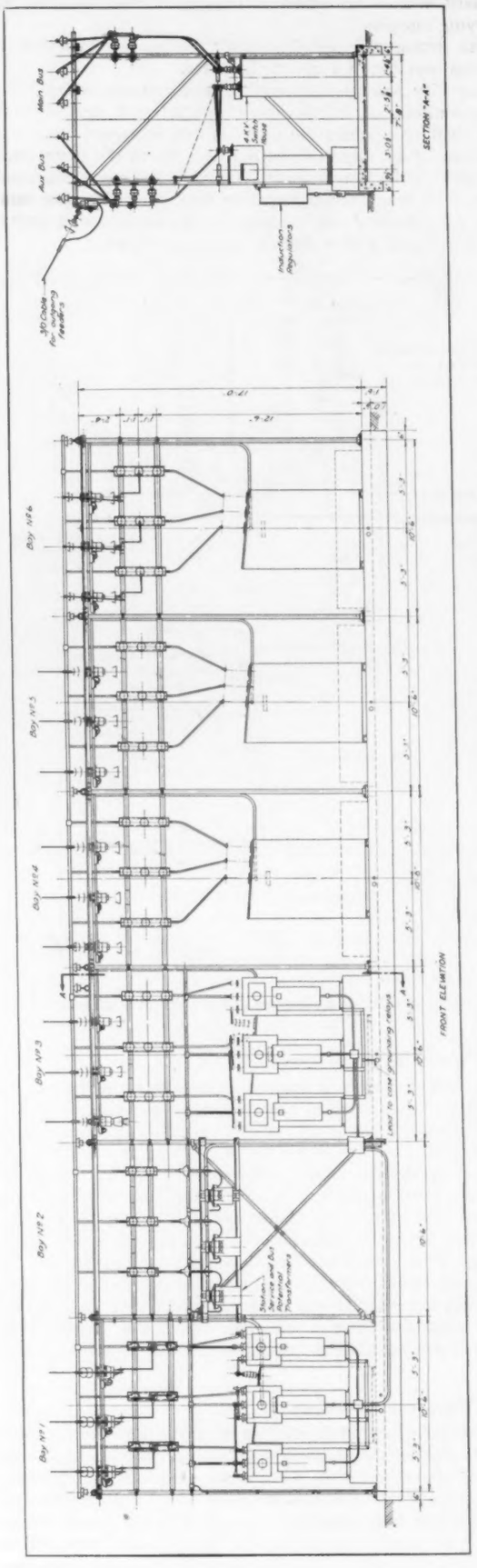


*Fig. 8. 4-kv. bus structure at King City substation, elevation and section*

Induction regulators are equipped with self-contained current and potential transformers. The regulator cases in each three-phase bank are tied together with a copper bus and grounded through a grounding relay. In the event of a regulator breakdown the case grounding relay operates to trip the feeder breaker and lock out the reclosing relay, to prevent reclosing into a faulty regulator.

A small bank to supply both station power and three-phase bus potential is mounted on the structure.

One of the 4-kv. feeders supplies a 750-kva. bank of transformers stepping up to 11 kv. to handle a long feeder running south from the station.

*General —*

Due to the location of feeder panels at breaker positions on the bus structure, the only need for a building is to house a small panel for total metering, storage battery and charging equipment, telephone, and miscellaneous supplies and tools. This is provided in a small corrugated iron building, 10 x 10 ft., inside dimensions, with a concrete floor and steel frame.

A small cottage for the maintenance man covering this territory is located adjacent to the substation and his duties include such switching as is necessary in connection with the 60-kv. lines. A low voltage alarm and lockout alarm on the reclosing relays are carried to the cottage.

*Summary —*

It may be noted that the type of construction employed at this station provides for materially increasing the output without any additional expense other than for a 60-kv. oil circuit breaker, larger transformers, and additional feeder regulators. New 4-kv. feeders can be added easily, and induction regulators can be installed on any feeder with very minor changes. At the same time the initial expenditure has not been increased beyond a sum commensurate with present requirements.

Incidentally, the Pacific Gas and Electric Company has found that for the small rural substation with a primary voltage of 60 kv., where some of the wiring must be exposed, there is no form of construction for various substation structures more economical than standard iron pipe frameworks of the type described. The expense of detailing, always present where structural steel is employed, is unnecessary and erection costs are extremely low. Changes in design or alterations required during the process of construction cause no serious trouble, inasmuch as most of them can be accomplished by sliding pipe up or down or along the structure, or adding members where required. Another cardinal principle to be remembered in connection with small and inexpensive substations is that construction expense forms a large portion of the total, and fittings and equipment cannot be built or assembled in the field as cheaply as they can be purchased.

The 4-kv. bus structure represents an investment of approximately $1,200 per feeder, exclusive of oil circuit breakers and regulators, the pipe structure itself costing only $150 per bay. Expense for conduits and control wiring is negligible, covering only total metering, convenience outlets, and incidental wiring.

It is felt that this type of station gives entirely adequate service to an important rural load, with an investment not out of line with the revenue.

## Davis Substation*

Necessity has led to the establishment of a number of sectionalizing and switching stations on the 60-kv. network of the Pacific Gas and Electric Company. This network consists generally of a number of long 60-kv. lines originating at some of the smaller hydro-electric power houses and terminating at substations, or other load centers, with a number of small distribution stations tapped off at points along the lines. To limit interruptions to a comparatively small area, it becomes necessary to install, at strategic points, equipment to sectionalize these lines automatically. In addition to the above function, the sectionalizing station ordinarily serves as a distribution station for the surrounding area.

Davis substation, approximately 13 miles west of Sacramento, which has served for many years as a 60-kv. switching center, has been entirely rebuilt within the past year and serves as a good illustration of the latest practices of the Pacific Gas and Electric Company in connection with construction for this particular type of station.

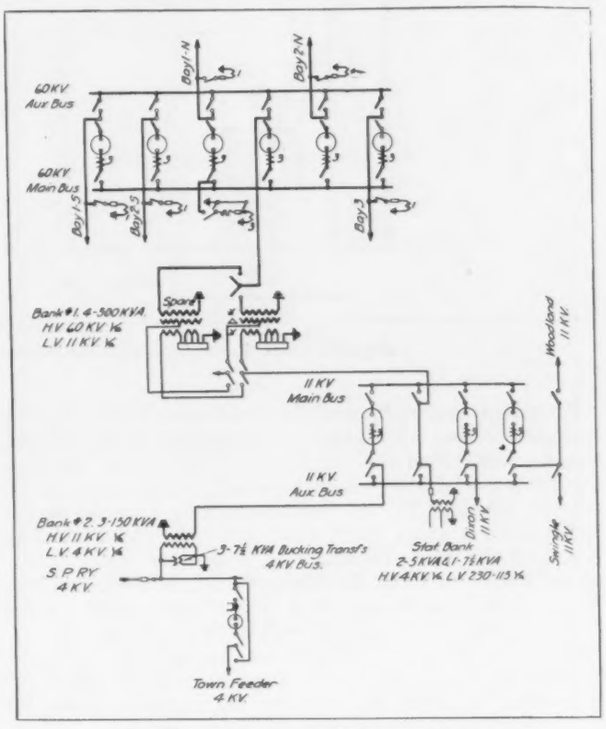
60KV Aux Bus
60KV Main Bus
Bay 1-N
Bay 2-N
Bay 1-S
Bay 2-S
Bay 3
Spare
Bank #1, 4-500 KVA. HV 60 KV. Y6 LV 11 KV. Y6
11 KV Main Bus
11 KV Aux Bus
Woodland 11 KV
Davis 11 KV
Swingle 11 KV
Bank #2, 3-150 KVA HV 11 KV. Y6 LV 4 KV. Y6
3-7½ KVA Bucking Transf's 4 KV Bus.
Stat. Bank 2-5 KVA & 1-7½ KVA HV 4 KV. Y6 LV 230-115 Y6
S. P. RY 4 KV.
Town Feeder 4 KV.

*Fig. 9. One-line diagram, Davis substation.*

*High Voltage Equipment —*

The high voltage equipment at Davis provides automatic sectionalizing facilities for five 60-kv. lines for a feeder from the 60-kv. bus to a 1,500 kva., 60/11-kv. distribution transformer bank. The 60-kv. bus structure is built of structural steel and occupies an over-all ground area 29 ft. 6 in. wide x 126 ft. long. The buses are 20 ft. above the ground and the central portion of the structure extends to a height of 36 ft. 6 in., to provide a deadend support for incoming lines. Group-operated disconnecting switches are mounted on the structure and oil circuit breakers are mounted on concrete foundations under the buses.

*Main Transformer Bank —*

The main transformer bank consists of three 500-kva. self-cooled transformers and one spare, transforming from 60 kv. grounded star to 11 kv. grounded star. Double-throw transfer switches are provided on both high and low voltages for transferring the spare transformer to any phase. These switches and the transfer buses are mounted on a typical transformer bus structure consisting of latticed steel poles and pipe framework. The 11-kv. output of the bank is regulated by means of four automatically operated tap changers, functioning under load. These tap changers are of the company's design and have been described in previous reports.

* By C. E. Baugh.

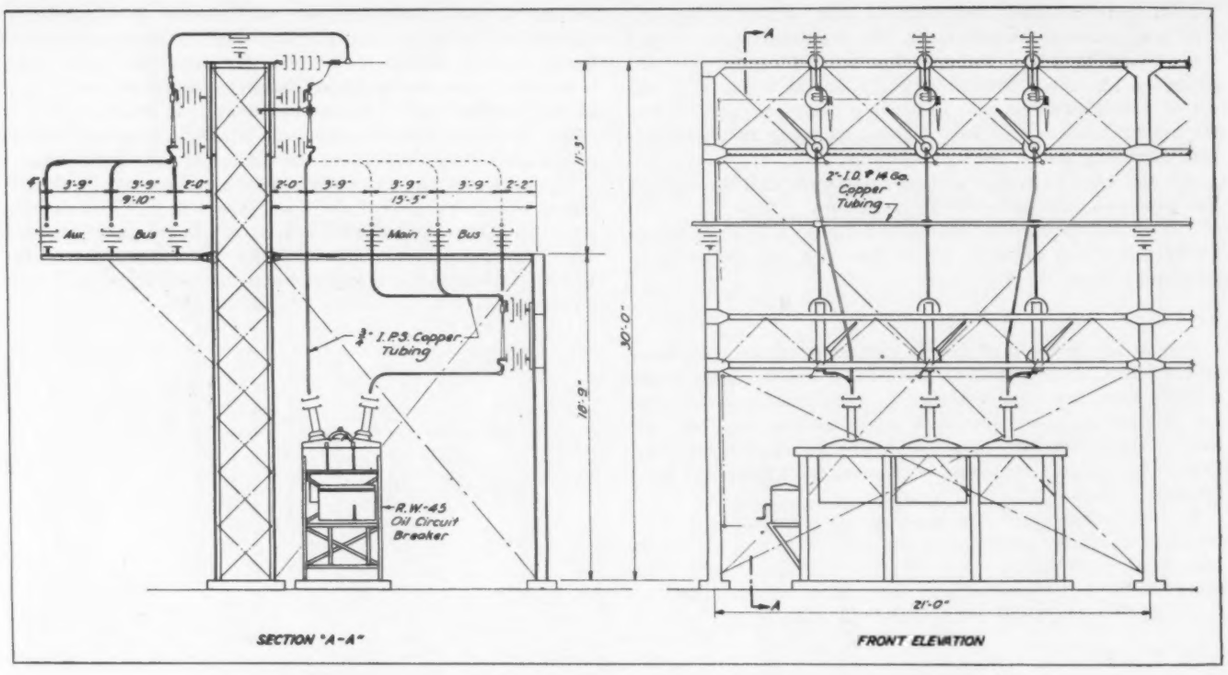


*Fig. 10. 60-kv. bus structure, Davis substation. End view on left and elevation at right.*

Protection against internal faults is secured by tying the transformer and tap changer cases together with a copper bus, insulated from the structure, and grounding this bus through a special low-ratio current transformer with a heavy primary winding. This current transformer actuates an instantaneous overload relay which trips the 60-kv. breaker supplying the bank. Inasmuch as most transformer faults on the Pacific Gas and Electric Company system are breakdowns to the core or case, it is evident that practically all cases of transformer trouble will be detected, as soon or sooner than by the use of differential relays. At the same time, the cost of the former protection is a small fraction of the cost of the latter, and much smaller transformers can be so protected at a commensurate expense.

*Low Voltage Equipment —*

The 11-kv. bus structure is of an outdoor type, which has been standardized for this class of station. The general design is very similar to that of the 4-kv. structure installed at King City substation and described elsewhere in this report. The framework is built of 2-in. and 1¼-in. standard iron pipe, with clamp fittings throughout. Buses are ¾-in. copper tubing and feeder connections are ½-in. copper tubing, assembled with lamp type connectors and terminals. Oil circuit breakers are outdoor type, with swinging relay and metering panels mounted in steel housings on the breaker frames.

The breakers are equipped with 24-volt d.c. motor operators, wound type current transformers inside the tanks, and automatic periodic reclosing relays. Each breaker is a totally self-contained unit and the construction expense for installation and wiring is almost negligible.

Three bays of the bus structure supply three 11-kv. feeders and a fourth circuit feeds a bank of three 150-kva. transformers, transforming from 11 kv. to 4 kv. for the load in the town of Davis. One 11-kv. feeder leaves the structure overhead and two in lead cable underground, the structure being equally adaptable to either type of take-off.

The structure is equipped with main and auxiliary buses, with disconnecting switches to isolate the breakers and to connect the lines to the auxiliary bus, and grounding switches for each line, mechanically interlocked with the disconnecting switches. The main buses are 2-in. No. 14 gage copper tubing and all other connections are ¾-in. copper tubing. All tee-connectors, couplers and other bus fittings and all tubing and wire terminals are full clamp type. The structural and electrical design was made by the company and the entire equipment, inclusive of breakers, supplied ready for erection by a local manufacturer. This construction lends itself admirably to the installation of a "fault bus" scheme for protection against bus faults, although this was not installed.

Oil circuit breakers are actuated by motor-wound spring-operating mechanisms from a 24-volt storage battery. The five lines are each equipped with power directional relays and directional residual overcurrent relays set to trip a power flowing out from the bus. In taking a breaker out of service for inspection or maintenance, the auxiliary bus provides a means for transferring that line to any one of the other breakers without interrupting service.

The 11 4-kv. bank is installed on a concrete foundation and inclosed with removable screens. A pipe framework over the transformers carries the 4-kv. bus, with an oil circuit breaker on one end and three expulsion fuses on the opposite end. The 4-kv. oil circuit breaker with its control and metering panel and reclosing relay is mounted in a steel housing, and disconnecting and bypass switches are provided on the structure. The fuses are for a circuit to two small motor-generator sets located in the substation building, supplying signal service to the Southern Pacific Railroad.

*Switchboard —*

A control switchboard for the 60-kv. lines is installed in the old substation building, which formerly housed the entire station. The building also houses a 24-volt storage battery, charging set, light and power panel boards and miscellaneous station supplies and tools. An alarm annunciator is provided, which shows by means of illuminated panels, the class of equipment which has caused an alarm.

*Conclusions—*

Every provision has been made to operate this station with one attendant living adjacent to the station, on duty 24 hours. There is no apparent reason why a station, with even a comparatively large amount of 60-kv. switching, cannot

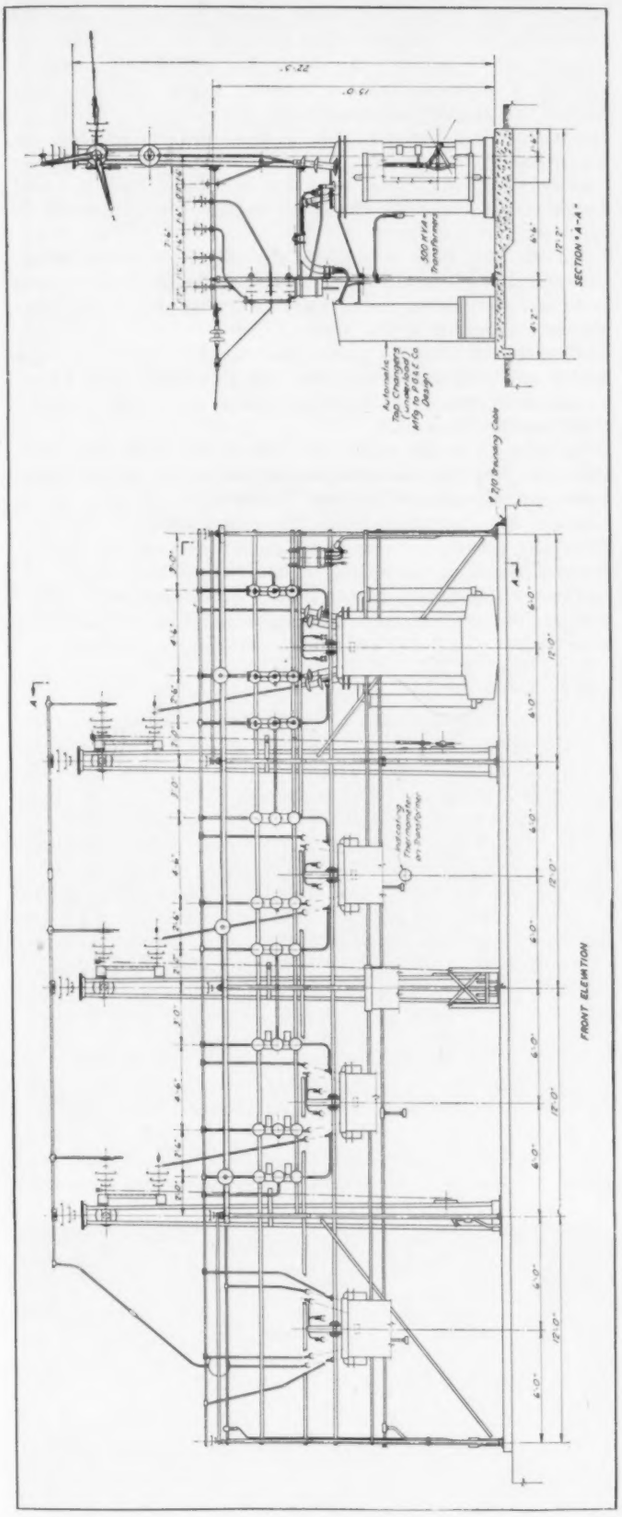


*Fig. 11. 1,500-kva. transformer bank. Davis substation. Note automatic tap changers.*

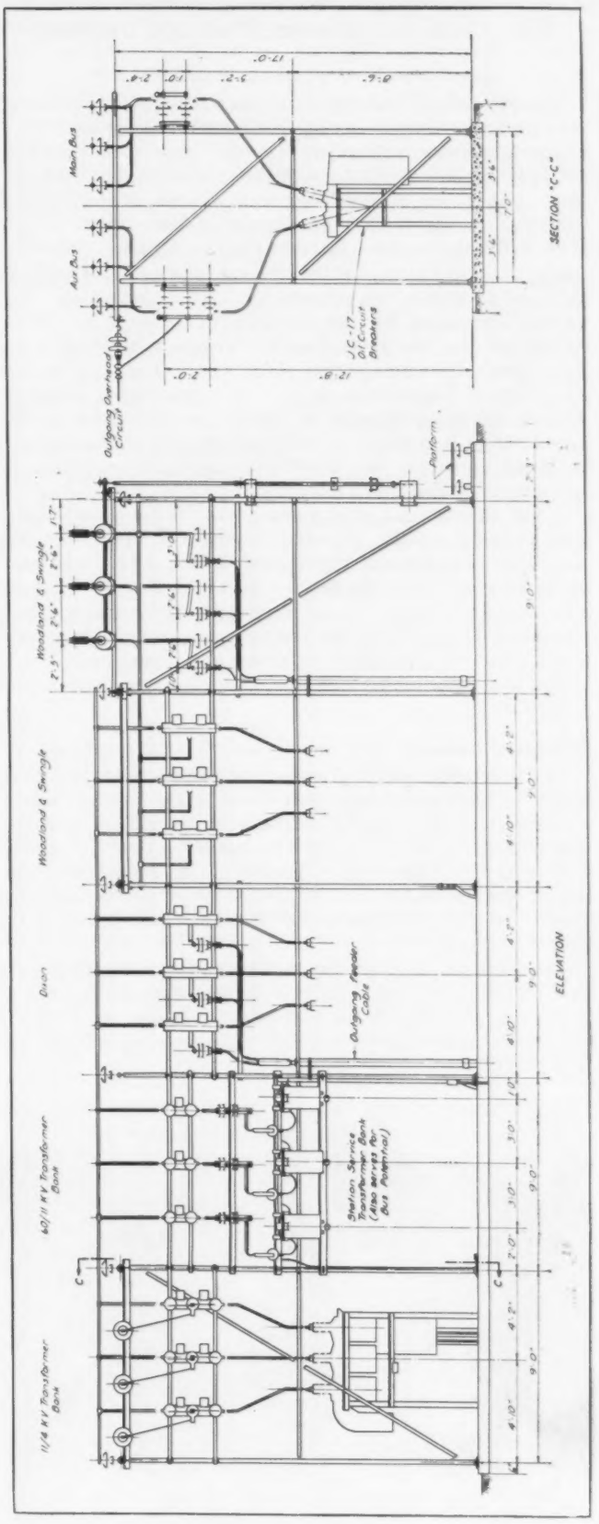


*Fig. 12. 11-kv. bus structure. Davis substation.*

take care of itself, if the proper automatic protective and reclosing features are provided. The quality of service required from the central station companies has become such that money must be put into equipment which can function without an unduly high operating expense, at the same time occasioning no excessive capital expenditure.

It is felt that the type of substation here described meets these requirements from every standpoint.

## *Substation Design Practices of The Southern Sierras Power Company**

### San Bernardino Substation

San Bernardino substation is the result of a reconstruction program carried out at this station during 1926-27, in order to provide adequately for the important switching, voltage regulation and distribution requirements of this section. San Bernardino substation is located at the southern terminus of our main transmission system, which extends some 240 miles southward from Control Station, (near Bishop), of Inyo County. Since the reconstruction of 1926-27, referred to above, the importance of the station has been further increased by the addition in 1929 of a 110-kv., 30,000-kva. tie line from San Bernardino substation to the Seal Beach tidewater steam plant of the Los Angeles Gas and Electric Corporation. It is at this time being somewhat further expanded in order to provide service to the 100-kv. transmission line which is being constructed to Hoover Dam in order to supply the 15,000-kva. construction power requirements of the dam contractor.

From this station also radiate two 88-kv. transmission lines to the Coachella, Imperial, Blythe and Yuma Districts, six 33-kv. distribution circuits, one 33-kv., 6,000-kva. interconnection with the Southern California Edison Company and one 66-kv., 6,000-kva. interconnection with the Southern California Edison Company. On the same property is a small steam plant of approximately 10,000 kva. capacity.

The five main sections of this substation are described as follows:

*Operating Building —*

The substation building consists of three stories and basement, reinforced concrete, steel frame, class A construction, and is specially designed and braced to withstand earthquake shock, as well as to give a minimum fire risk. It has 11,720 sq. ft. of floor space, provides room for another condenser (which will be added in 1931) and can be extended readily to the east, because of a hollow wall provided for future expansion.

The general architectural features of the building have been carefully worked out and its pleasing appearance is somewhat accentuated by well planned lawns, some 30,000 sq. ft. of space under the 33-kv. feeders being utilized for this purpose.

*Fig. 13. General view, San Bernardino substation, The Southern Sierras Power Company.*

The south half of the building is the condenser room. This has no basement and is open from floor to ceiling, with a 50-ton electrically operated crane on a track extending the length of the room. A transformer pit is provided, with track and car facilities for moving any of the transformers from their standing locations. The northern half of the building has a basement, with access through a concrete duct to the No. 1 condenser and access to the water pipe and conduit tunnel, which runs under the transformer settings for the whole length of the transfer track. This basement houses the starting equipment for the condenser, the large condenser field rheostat, the pumps and motors for the water-cooling system and the local light, heat and power transformer bank, with a power and light control panel board. All power cables from the outside are terminated in this room.

On the first floor are located the 15-kv. oil circuit breakers with their disconnecting switches. These breakers and switches are placed in concrete cells and form two rows nearly the length of the room.

The second floor is given over to the 6,600-volt buses which are installed in concrete cells. Although easy access is had to the bus and taps at any point, it is fully protected from accidental contact.

In addition to the buses, over eleven miles of metal conduit, carrying the control wires for the entire station, terminate on this second floor at the terminal cabinets. These cabinets are directly beneath the switchboard on the next floor and provide a means of handling the control circuits without changing the wiring on the switchboard itself.

The switchboards, battery, and superintendent's office occupy the top floor, from the windows of which a good view may be had of the 132 and 33-kv. switching structures.

*132-kv. Section —*

The tower lines terminate in the 132-kv. switching structure, which occupies nearly one-half of the space covered by the entire station. There are eight 132-kv. oil circuit breakers, which are all controlled electrically from the switchboard on the top floor of the building. These breakers provide protection on the tower-line high tension side of the transformers, opening automatically upon a heavy overload or short. One breaker permits switching to the transfer bus. All oil circuit breakers are provided with motor-operated air-break bypass switches and hand operated air-break disconnecting switches, so that they can be disconnected from the line entirely, to permit work to be done upon them, with the buses and circuits remaining energized. Suitable station type arresters are provided for all lines.

The buses are insulated and spaced for operation at 132 kv., but are now operating at 95 kv. to feed five step-down transformer banks totaling 66,000 kva. for condensers, 88-kv. loop, and 33-kv. loop systems, and one 30,000-kva. auto transformer bank, stepping up to 110 kv. for the Seal Beach tie line. An electrically operated 110-kv. oil circuit

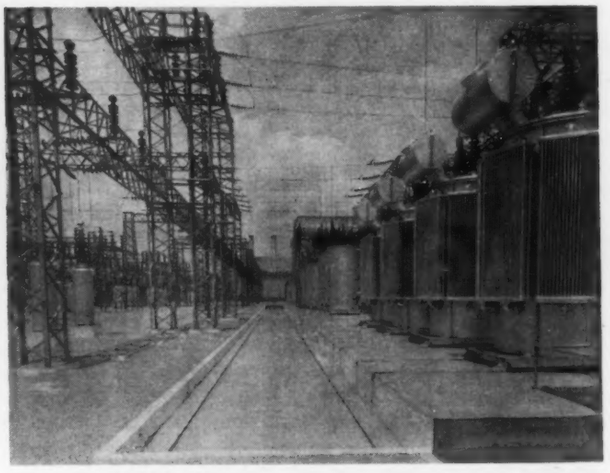

*Fig. 14. Transformer banks and transfer rack, San Bernardino substation, The Southern Sierras Power Company.*

* By M. L. Baden, A. F. Ayres, and B. Singleton.

breaker with motor-operated air-break bypass switch and hand-operated air-break disconnecting switches protects this auto-transformer bank on the line side.

The buses are of 250,000 circ.mil bare copper deadended to the structure by strings of 10-in. disk insulators, nine insulators being used in each string.

88-*kv. Section* —

The 88-kv. structure occupies less than half the space required by the 132-kv., but is of the same general type, viz:— Steel structure supporting suspension type operating and transfer buses, deadended by strings of six 10-in. disk insulators per string, but using 4-0 9.C.S.R. conductor instead of the copper used on the 132-kv. side. Two 87-kv. lines, which form the loop into Imperial Valley, take off from this structure. Five electrically operated oil circuit breakers protect the transformers on this side, and provide switching and transfer facilities. As on the 132-kv. side, these breakers may be disconnected from the line for repairs by air-break switches and service carried on through motor-operated bypass air-break switches. Suitable station type arresters are provided for both legs of the 88-kv. loop.

33-*kv. Section* —

The communities served by The Southern Sierras Power Company in the Riverside district are at distances from the San Bernardino substation that make 33,000 a satisfactory distribution voltage.

There are twelve 33-kv. outdoor electrically operated breakers with disconnects, seven for outgoing lines, three for transformer banks, one for transfer switching and one for ground bank protection. Suitable station type arresters are also provided for all lines. The outdoor main and transfer buses consist of 1-in. copper tube carried on pin type bus supports.

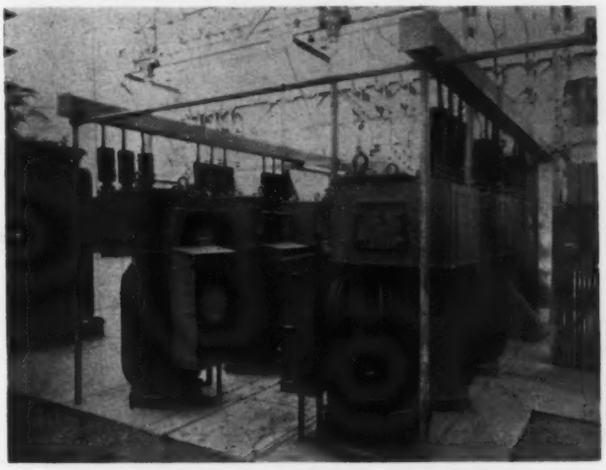

*Fig. 15. Typical outdoor regulator installation, San Bernardino substation, The Southern Sierras Power Company.*

6,600-*Volt System*—

The 6,600-volt buses and breakers are of indoor cell type construction, with double buses built up of ¼x4 copper bars on unit bus supports. Electrically operated breakers and disconnects in duplicate are provided for three transformer banks, one synchronous condenser, two steam-plant tie feeders and one local heat, light and power system, so that every one of these circuits may be served from either bus at will.

The steam standby plant of approximately 10,000 kva. capacity is at the north end of the property, generating at 6,600 volts, and is connected to this 6,600-volt bus by two underground feeders, each consisting of three 1,000,000 circ.mil varnished cambric, lead covered cables carried in fiber ducts encased in concrete and terminated in ventilated concrete risers and pot heads. The steam plant building also houses a 6,250-kva. 50/60-cycle frequency changer set, interconnecting our system with that of the Southern California Edison Company.

*General* —

The property is located in the city of San Bernardino, California, and occupies an area of about seven acres.

The operating building is centrally located with reference to the switching structures and forms a natural division between the 88-kv. and 33-kv. sections. In this location it shows up to good advantage from the south. The 88-kv. and 33-kv. structures are divided from the 132-kv. structures by the straight line of the transformer foundations, which is 484 ft. long and runs north and south in a plane with the west wall of the building.

The railroad spur serving the steam plant was extended through to Mill Street, nearly parallel to and adjacent to the west line of the property. A standard-gage track 300 ft. in length was constructed, leading from this spur through the 132-kv. structures and directly into the operating building. A 50-ton jib crane, placed at the intersection of this track and the spur, permits the handling of heavy equipment from the railroad cars to our own building and transformer

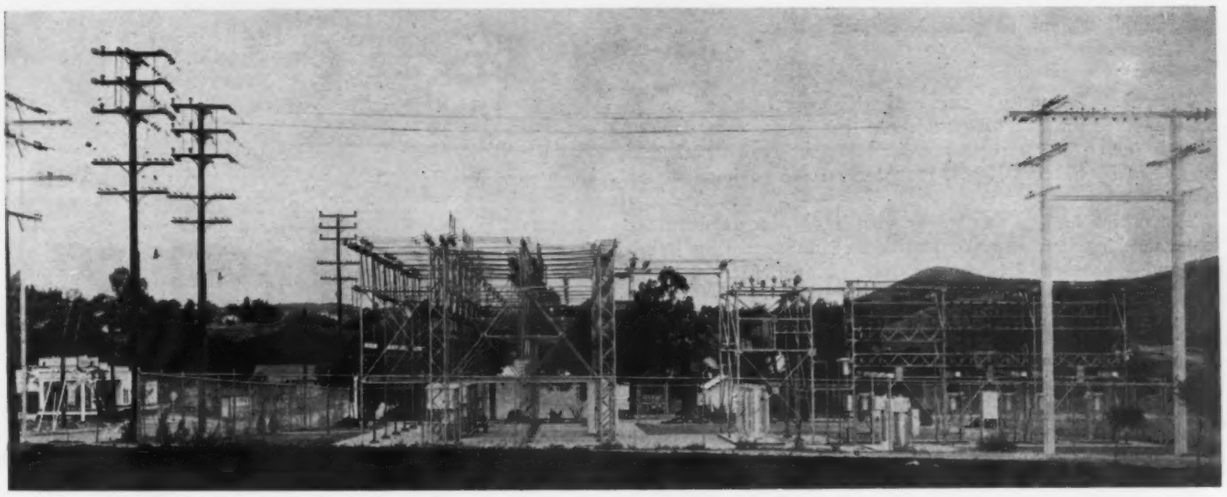

*Fig. 16. Elsinore substation—typical major type of semi-rural substation, 33,000-2,300/4,000 Y, The Southern Sierras Power Company*

transfer tracks, an ideal arrangement so far as trackage is concerned. A 5-hp. motor-driven hauling winch was also provided for moving cars, etc., in the substation yard.

The substation yard and approach to the operating building are surfaced with oil and gravel and the substation is completely inclosed, with a 7-ft. all-steel chain link fence. The substation lighting is mainly provided by ornamental standards with reflectors, supplemented at a few points by flood lights and bracket lights on the structures, while the operating building is flood lighted.

In the entire station layout and operating building design, future requirements were carefully considered and every facility for future expansion provided.

### Elsinore Substation

Elsinore substation is an important switching center on the 33-kv. loop distribution system fed from the San Bernardino substation of The Southern Sierras Power Company and serves an extensive agricultural district at 2,200 volts. This outdoor substation, constructed in 1930, is briefly described as follows:

*33-kv. Section —*

This section consists of a five-bay steel structure with a double bus of ¾-in. copper tubing on pedestal type insulators, with provision for four 33-kv. lines and one transformer bank. All line bays are equipped with hand-operated oil circuit breakers, single-pole disconnecting switches, air-break selector and bypass switches, and line type lightning arresters. The transformer bay is equipped with air-break manually operated selector and bypass switches and high voltage fuses. Automatic sectionalizing relay equipment is provided for line to line short circuits and line to ground faults.

*Transformers —*

The transformer structure is a two-bay steel structure with high and low voltage buses of ¾-in. copper tubing on pedestal type insulators, and with stick operated disconnecting switches. Through 150-kva. transformers, 33,000/2,200 volts, are mounted on a concrete foundation.

*2,200-Volt Section —*

The 2,200-volt bus structure is a through bay steel structure with ¾-in. tubing main and transfer buses, and contains equipment for four feeders and one total circuit. Hand-operated automatic oil circuit breakers with disconnecting and bypass switches are provided for each circuit. Two 48-kv. induction regulators furnish bus regulation. Outgoing circuits are equipped with line type lightning arresters. Three 1½-kva. transformers connected to the 2,200-volt bus in grounded star, supply a bank of ground detector lamps.

*General —*

The substation yard is surfaced with gravel and oil and is inclosed with an 8 ft. all-steel chain link fence. Two sides of the lot facing city streets are landscaped. Yard lighting is furnished by bracket lights, mounted on the various station structures.

The entire design was made with a view toward future expansion, particularly the addition of an operating building and synchronous condenser, both planned for the latter part of 1931.

### Somerton Substation

Somerton substation, constructed in 1928, is a typical medium-capacity rural distribution substation, operating from the 33-kv. system of The Southern Sierras Power Company. Essentially it consists of the following items, each of which is briefly described:

The entire station consists of a two-bay steel structure with facilities for two 33-kv. lines, a transformer bank and three 4,000-volt feeders.

The 33-kv. portion of the equipment is a single bus of ¾-in. copper tubing or pedestal insulators, with group-operated disconnecting switches for each side of the 33-kv. loop.

The transformer bank consists of three 150-kva. single-phase transformers, connected 33,000 volts delta/4,000 volts grounded star. The high voltage side of the bank is provided with a group-operated disconnecting switch, choke coils, fuses and station type lightning arresters.

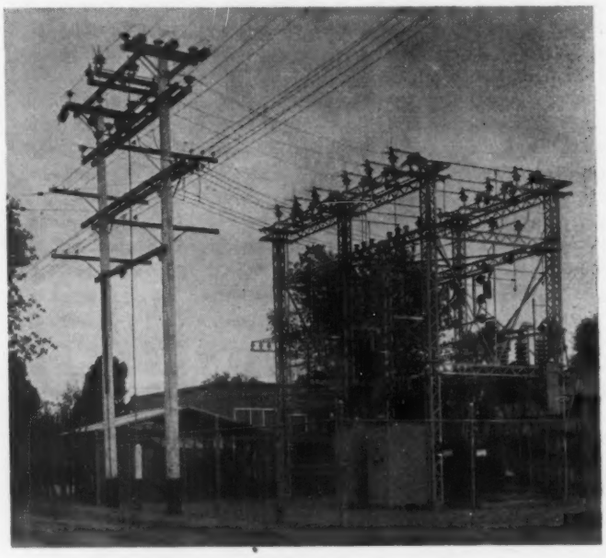

*Fig. 17. Somerton substation, Arizona—typical medium capacity rural substation (for two incoming supply lines), The Southern Sierras Power Company.*

4,000-volt equipment consists of main and transfer buses of ¾-in. copper tubing, with disconnecting and bypass switches and automatic reclosing oil circuit breakers in steel houses for each of the two 4-kv. feeders. Each feeder is equipped with line type lightning arresters and choke coils.

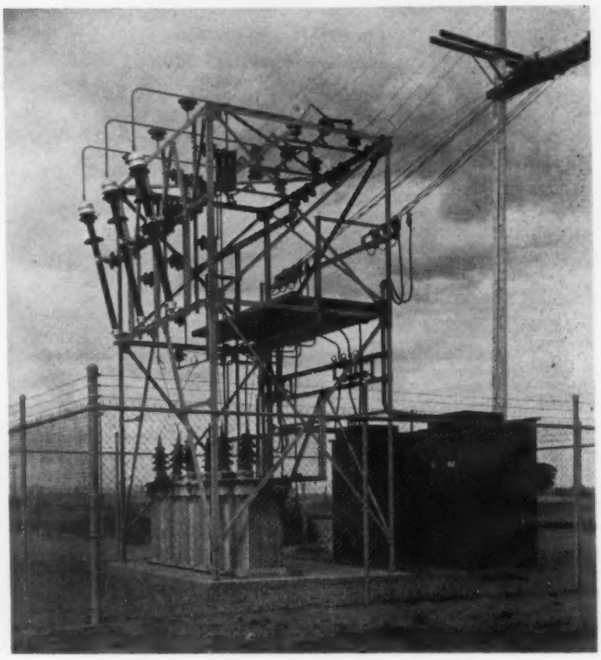

*Fig. 18. Avenue B substation, Yuma—typical small capacity rural substation, The Southern Sierras Power Company.*

The substation yard is surfaced with gravel, and is inclosed by an 8-ft. all-steel chain link fence. The ward is illuminated by bracket fixtures mounted on the structure.

### Avenue "B" Substation—Yuma

Avenue B substation is typical of the smallest rural distribution substations operating from the 33-kv. network of The Southern Sierras Power Company.

The station consists of a one-bay steel structure, with facilities for one 33-kv. line, transformer bank and two 2,200-volt feeders. Transformer bank switching and protection is provided by a group-operated disconnecting switch, fuses, choke coils and line type lightning arresters.

Three 75-kva. single-phase transformers, 33,000/2,200 volts, comprise the transformer bank.

The 2,200-volt feeders are No. 1/0 stranded copper cable with 5,000-volt varnished cambric insulation, supported by strain insulators. Each of the 2,200-volt feeders is equipped with a hand-operated oil circuit breaker in a steel switch house, and with outdoor disconnecting switches between the bus and the breaker. The lines are provided with choke coils and lightning arresters.

The station yard is surfaced with gravel and inclosed with an 8-ft. all-steel chain link fence.

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## *Camden Substation — San Joaquin Light and Power Corporation**

Camden substation was built in the early part of 1930 to serve an agricultural load that had grown to such proportions that it could not be handled properly from any of the existing stations. The best location for the substation as determined by the load center was several miles from any transmission line, so it was necessary to build a 5.4-mi. tap from the Caruthers-Henrietta 70-kv. line to serve the station.

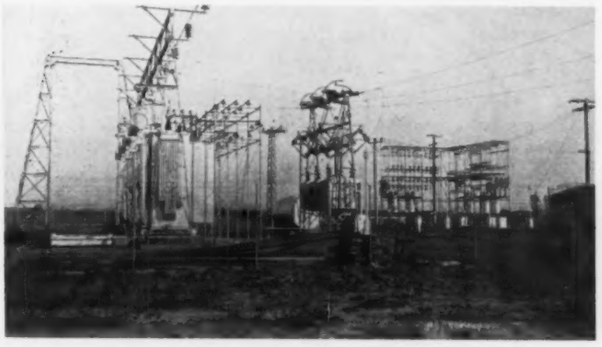

*Fig. 19. General view of Camden substation.*

This substation is outdoor type, the 12-kv. bus voltage is regulated by automatic tap changing equipment and the 12-kv. switches are all automatic reclosing. It is located on a 2-acre plot on one corner of two intersecting roads. This permits extending the 12-kv. feeders in four directions with a minimum of multi-circuit lines and no right-of-way to purchase. While there is only one source of power at present, the yard has been laid out to permit bringing in other feeds from the 70-kv. network in the future, and installing the necessary 70-kv. oil circuit breakers, towers, main, and transfer buses.

*Structures —*

Galvanized steel is used for the switch and transformer towers, for the transformer derrick and the steel poles. All

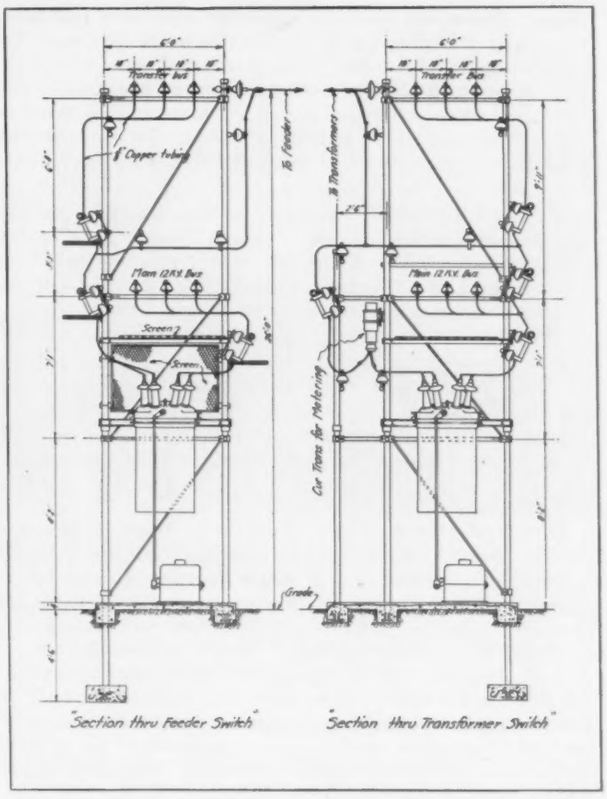


*Fig. 20. Typical details of 12-kv. structure, Camden substation.*

steel footings are galvanized and in addition painted with asphaltic paint to resist corrosion. The 70-kv. yard has only the transformer switch tower at present.

The 12-kv. transformer bus structure and 12-kv. switch and bus structure are of standard galvanized pipe, joined by fittings of our design. Verticals are 2-in., horizontals 1¼-in., and diagonals are 1-in. pipe. Pin type insulators of the 22-kv. class are used to support the buses. Bus supports and pins are of our own manufacture.

In the 12-kv. switch structure, suitable screen barriers are provided to protect maintenance men from live parts.

The structure contains both main and transfer buses. Provision is made for a master switch and five feeders, and future extension may be made. It is built L-shaped, to simplify the getaway of the feeders and avoid buck arms on the corner pole. Potential transformers for metering and for future relays are located at one end of the main bus and station service transformers at the other.

*Oil Circuit Breakers —*

All oil circuit breakers are outdoor type, motor-operated, remote-controlled. The 70-kv. transformer switch is 400-amp., 4-break type with bushing type current transformers, formerly a 110-kv. breaker that had been outgrown by the system. It was felt that for 70-kv. service as a transformer switch, where its duty would be comparatively light, its useful life could be lengthened many years.

The 12-kv. master switch is 600 amp. and the feeder switches 400 amp. All are 6-break type, 15-kv. rating, with bushing type current transformers, and are rated at 150,000 kva. interrupting capacity. All the 12-kv. breakers are automatic reclosing. This type of switch permits of a compact and economical bus structure.

*Transformers —*

Three self-cooled single-phase transformers, 3,000-kva. 69,500Y/13,630Y with 2,300-volt tertiary winding supply the

* By E. W. Otto.

station. These are connected star-star and have full automatic tap changing equipment on the secondary side for voltage regulation of the 12-kv. bus. Both 70-kv. and 12-kv. neutrals are tied into the ground network of the station. The 70-kv. neutral is arranged so that readings may be made of the neutral current if desired. A current transformer and ammeter are installed in the delta of the tertiary for reading the current.

A spare transformer is arranged so that it may be put into service by changing jumpers without moving any of the transformers. The transformers are truck-mounted with roller-bearing wheels, and transfer track and transfer car with roller-bearings are installed to facilitate handling.

A derrick for use with chain blocks is provided for servicing transformers. Oil tank and piping are provided for handling both transformer and switch oil. Portable filter presses are used to handle the oil and a common system of piping is used for both oils. The oil system is graded to drain into a sump for the removal of condensate or oil.

*Switchboard, Control Wiring and Relays —*

Ebony asbestos in sheets 42x48x¾ in. thick is used for panels. Relays, meters, control switches, etc., are grouped vertically for each circuit. A single ammeter with switch is installed on each feeder. These are not exactly accurate, as they are on bushing type current transformers, but are sufficiently so to give an indication of the load on the feeder. A 6-pen recorder with 7-day chart indicates any tripout on the feeders. All control cables come into a pit at the back of the board and up to a terminal board on the switchboard. A position is provided on the regular switchboard for station service and battery--charging equipment. Indicating lights are provided, but no mimic bus.

Control wiring is all lead-covered armoured cable with corrosion-resisting covering laid directly in the ground.

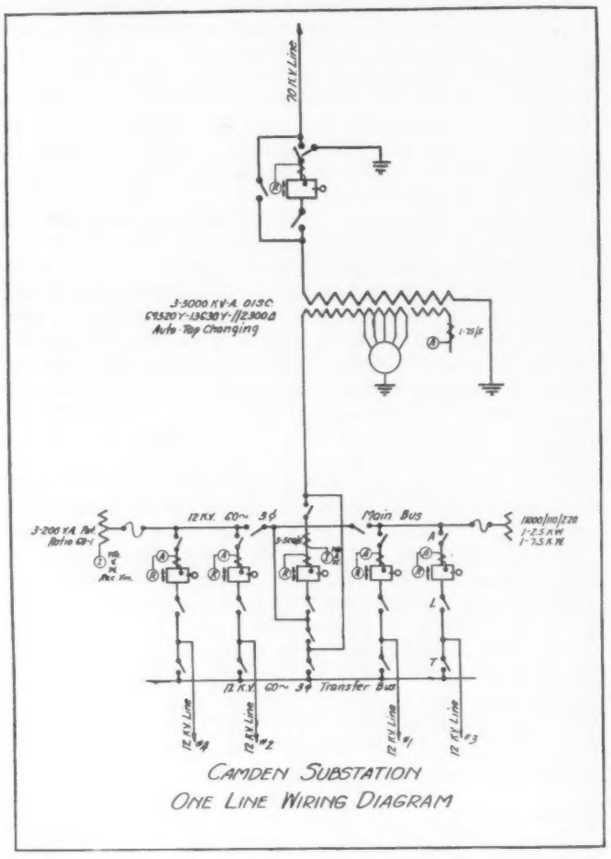


*Fig. 21. One-line diagram, Camden substation.*

Induction type over-current relays are used throughout for electrical protection.

*Battery and Equipment —*

Control battery is 40-volt, 200-amp.-hr. capacity. This is kept on trickle charge by a 750-watt motor-generator set. A voltmeter and ammeter indicate condition of the battery and charging rate. A no-voltage release is provided to disconnect the generator in case of power failure. Separate d.c. control buses are run out into the yard for the 70-kv. and 12-kv. circuit-breakers. A ground indicator is provided for grounds on the control battery circuits.

*Substation Building—*

The substation building is concrete brick, plastered inside and out. It is 17x29 ft. and includes a switchboard room with its switchboard, battery cabinet, motor generator and operator's desk, a relief operator's quarters with cot, electric stove, sink, cupboard and furnishings and a lavatory. The relief man's quarters are provided at stations where the operator is on 24-hour duty, so he does not have to stay in the regular operator's cottage.

*Station Ground —*

Four ground wells 20 ft. deep are installed, one near each end of the transformer structure and one at each end of the 12-kv. switch structure. These are all tied together in a common network by 3/0 copper wire. All steel structures, the transformer neutrals, and the well casing are tied into this system with 3/0 copper.

*Water System —*

An automatic pressure system supplies water to the cottage and substation yard. Hydrants are located so that the electrical grounds may be dampened.

*Yard Lights and Power —*

Electroliers are used for illumination. The standards are of our own make, with concrete bases and pipe uprights. Provision is made in the bases for plug receptacles to supply power or extra lights in the yard.

*Operator's Cottage —*

A 5-room stucco house and 2-car garage were built for the operator. These are wired to conform with Red Seal standards. The operator is on duty 24 hours. It is also part of his duty to act as service man in the territory adjacent to the substation.

*Telephone and Alarm —*

A telephone is installed both in the substation building and in the cottage, connecting with the company's private lines. Protective equipment is installed in a rack outside, where the lines come in. The alarm is installed in the cottage, as well as in the substation.

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## *A Typical Transmission to Distribution Substation of the Southern California Edison Company Ltd.**

This station is known as Ganesha substation and is located on the outskirts of Pomona. Two 66-kv. lines are brought into a standardized 66-kv. rack structure, which also takes care of the 66/11 kv. transformer bank and a bus tie position. On this job the conventional main and transfer bus switching arrangement is used, although the construction is such as to permit going to double bus at any time. As shown in Fig. 22, the rack construction is of the "ground-supported bus" type, the design being the same as first brought out by

* By T. J. Lovell.

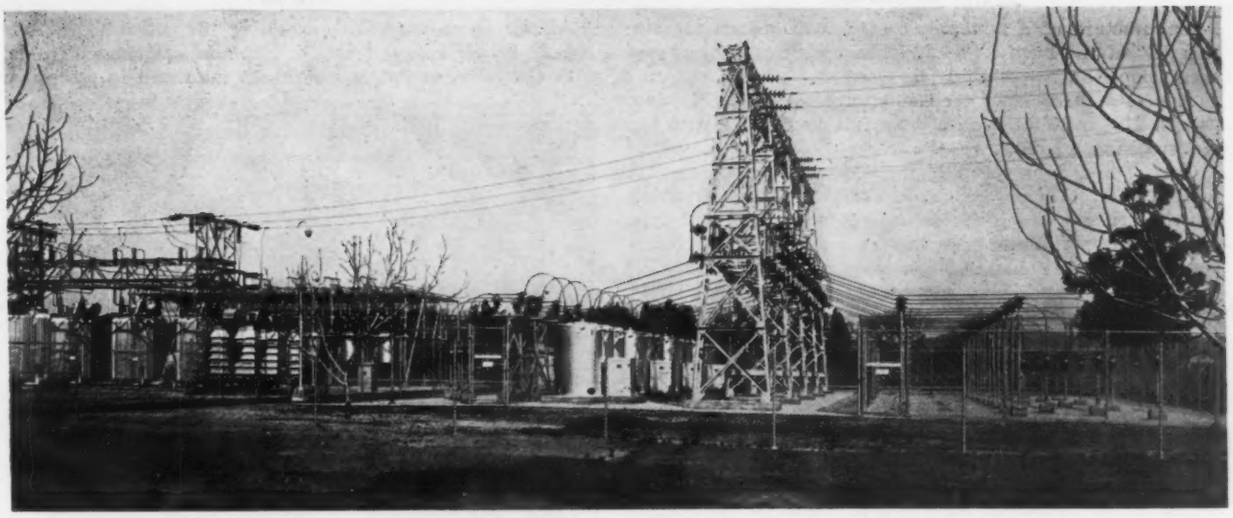

*Fig. 22. End view of 60-kv. bus structure.*

this company for 220-kv. installations, differing only in dimensions. In accordance with the present practice of this company, no arresters are installed on the individual 66-kv. lines, but one arrester is installed on the high voltage bus of the transformer bank, which has its own separate supporting structure. The bank, which is of three 3,000-kv. natural-cooled units, is provided with a spare, which is cut into service by means of movable taps.

The 11-kv. structure is of the standardized design, and takes care of five 11-kv. feeders, a transformer position and bus tie. The switching arrangement is the same as the 66-kv.,

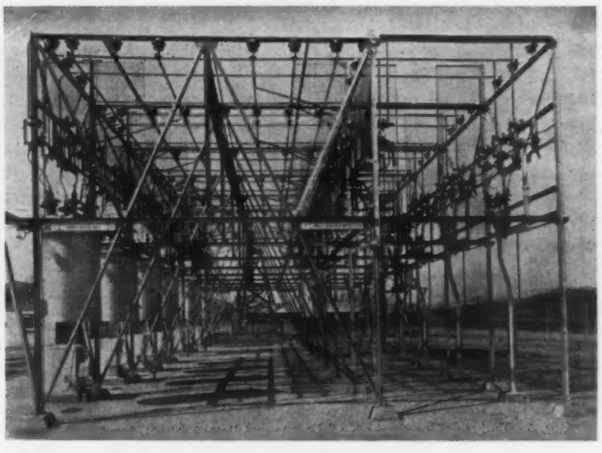

*Fig. 23. End view of 11-kv. bus structure, showing outgoing cables.*

viz., main and transfer bus. The breakers of both voltages are switchboard-controlled motor-operated, and the 11-kv. feeders and bus tie circuits are, in addition, automatic reclosing.

An oil storage tank and an oil piping system with vertical risers located near the breaker and transformer tanks, make possible the use of a portable pump and filter press outfit.

The structures are lighted by a combination of the flood lighting and local lighting methods.

It might be interesting to state that 85 per cent of the working drawings used in the construction of this station were standardized drawings.

## *Supervisory Control and Miniature Control Applications—Pacific Gas and Electric Company*

### West Point Substation

A direct wire system of supervisory control is being installed at West Point substation, approximately two miles west of Redwood City, which is to be the dispatching point.

The equipment provides for the control and supervision of two 60-kv. breakers and two 2,300-volt breakers, with provision for the future control and supervision of five additional breakers. Supervision is provided for the following:

D.C. control voltage failure
Control bus ground
A.C. voltage failure
Transformer water-pressure failure
Excessive transformer temperature
Open position of substation door

An additional point in the West Point equipment is devoted to metering of the transformer current, making a total of 16 points.

For the direct wire equipment, three common wires are required, with two for each point of control and supervision, one additional for each point of supervision only and two wires for each point of metering.

A snap switch is provided with the substation equipment, which permits disconnecting the contact circuit of the interposing relays for testing purposes only. This makes it possible to perform test operations up to and including the operation of the interposing relays without actually operating the circuit breakers.

A transfer switch is provided at the substation for transferring the control from the dispatcher to a local operator at the substation. The remote alarm indications previously noted are effective at the dispatcher's office regardless of the position of the transfer switch.

### Bellota Substation

There is on order for Bellota substation a 2-wire visual type of supervisory control equipment, which will provide for the control and supervision of one 220-kv. oil circuit breaker and two 220-kv. motor-operated disconnecting switches. The dispatcher's equipment will be located at Stockton, approximately twenty miles distant. The control line will consist of an open type 2-wire telephone line.

### Miniature Control

Manufacture of a minature control switchboard for station "G" of the Pacific Gas and Electric Company has just been completed.

This is a three-panel vertical steel board with 76x32-in. panels. This installation involves a full double bus, with bus sectionalizing breakers.

Control and supervision is provided for 36 breakers at present and ten in the future. In addition to the customary control key, red and green indicating lamps and push-type control button, each supervisory control escutcheon incorporates an amber disagreement lamp and a sectionalizing jack. Each circuit breaker nameplate has a white pilot light incorporated in it.

The rear of the board is totally inclosed and is provided with double steel doors at the rear of each panel. The complete assembly is 18-in. in depth and is self-supporting.

Each control wire is individually fused at one end with a ½-amp. fuse.

Glass-covered relays, incorporating four miniature contactors each, provide the red and green lamp, indicating source for the breakers.

Triplex flush-mounted illuminated-dial ammeters are used throughout.

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## *A Miniature Control Switchboard Installation*

## *Southern California Edison Company Ltd.**

As an experiment, in the attempt to lower the cost per kva. of substation construction, the Southern California Edison Company Ltd. has recently installed a miniature control switchboard with a supplementary telephone and unattended substation alarm panel in its substation at Lancaster. The full saving possible with this type of equipment was not realized on this installation, for the reason that this was a rebuilt substation and it was not practicable to locate all relay equipment at the rack.

This equipment was designed by the engineering department of the Southern California Edison Company Ltd. and built in the telephone division of their Alhambra shops.

### Control Equipment Board

The control equipment board, which is 3 ft. wide x 7 ft. 6 in. high, is made up of telephone equipment mounted on individual slate and steel panels on a steel frame. The control panels, of which there are three, one for each of the 66-kv., 11-kv. and 4-kv. groups of circuits and mounted one above the other, are of slate 10½ in. high and are planned and wired for an ultimate of fourteen double bus circuits. However, they are equipped only for the number of positions and type of position used.

The ammeter key panels, mounted directly below each control panel, consist of telephone switchboard keys mounted on a steel panel, 1¾ in. high, drilled and wired for full capacity, with unused positions filled with blank escutcheons. A similar panel used as a voltmeter key panel is furnished for potential indications and is located directly below the 4-kv. panels.

The meters are mounted on a steel panel, 21 in. high, located above the other panels, and consist of a large size wattmeter, two 3-in. round voltmeters and five ammeter groups, each consisting of three 3-in. round instruments, one for each of the 66-kv., 11-kv., 4-kv., and the two transformer groups. These small meters are used in conjunction with 5/0.1-amp. current transformers located at the protective relays. The relays for the audible alarm are mounted on a slate panel at the top of the board.

* By T. J. Lovell.

### Wiring

All wiring on the board, excepting the potential leads, is No. 22 double silk and cotton telephone switchboard cable, with the same, except in lead, from the board to protective

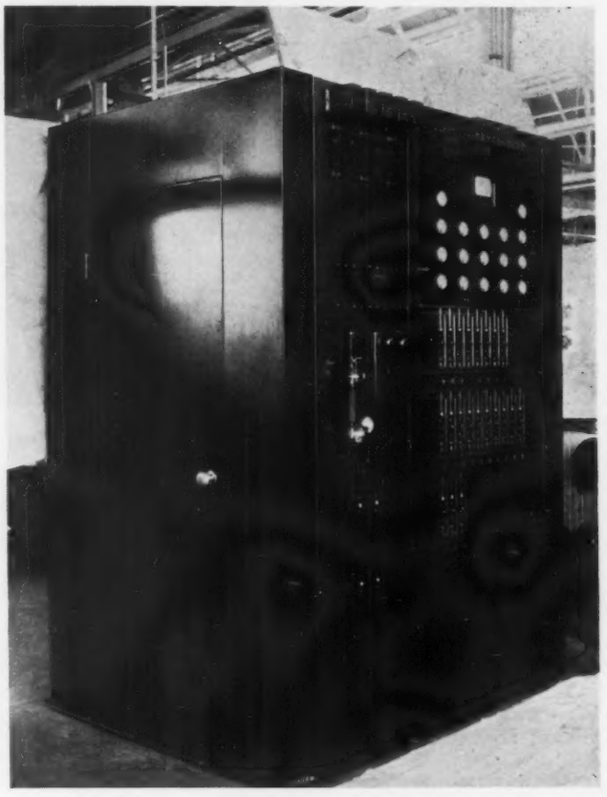

*Fig. 24. Completed miniature control switchboard.*

relays, 5/0.1-amp. transformers and pallet switches on circuit breakers. The wires in this cable are colored according to the standard telephone cable color code. The potential leads are in No. 19 rubber insulated lead-covered telephone cable. All of these cables terminate on soldered terminals at the bottom of the board at the rear, two strips of terminals for control and two for metering. The incoming cables terminate on the right hand terminals of each group shown vacant in the accompanying photograph. The cross-connecting between the incoming terminal and the equipment terminal is made with No. 22 flameproof telephone jumper wire, making a very flexible means of connecting the inside and outside equipment.

### Individual Circuit

The control equipment for the individual circuit consists of a white lamp, a red lamp, a key of the rotating-cam type, a green lamp and push-button key arranged from the top to bottom of the unit in the order named. Provision has been made at the top for the addition of a synchronizing jack when required.

For the operation of a breaker, the rotating key is turned to the open or closed position and the push-button key depressed. The indicating lamps will change on the operation of the breaker, as they indicate the true position of the breaker directly from the pallet switches on the breaker.

For an automatic operation, the indicating lamps first change on the opening of the breaker, from red to green. When this happens, the white lamp at the top, called the disagreement lamp, is lighted, indicating that the rotating key shows a different position than the actual position of the breaker. The white lamp and the audible alarm, which

is operated from a telephone relay in parallel with the disagreement lamp, may be de-energized by turning the rotat- breaker directly from the pallet switches on the breaker.

### Telephone and Unattended Substation Alarm Equipment Board

To the left of the control equipment board is located the telephone and unattended substation alarm equipment board. This board consists of the equipment on unit steel panels, mounted on a steel frame, and is the same type used throughout the Edison system. The telephone equipment consists of a grabaphone wall instrument, with its associated equipment, on a panel 4 ft. from the floor. Above are two dead-front looping and switching panels and above these are the ringers, located behind a grill, and a signal horn relay panel at the top. Below the telephone instrument are located equipment panels for alarms from four unattended substations. These are closed-circuited simplex alarms on the telephone lines and are furnished with direct current from a 24-volt rectifier. The comparative readings of the milliammeter on the rectifier panels are used to indicate the conditions of the lines from time to time.

In case of trouble at one of the unattended substations, the circuit is opened and permits a telegraph relay to fall back, energizing a red and white lamp on the alarm panel and an

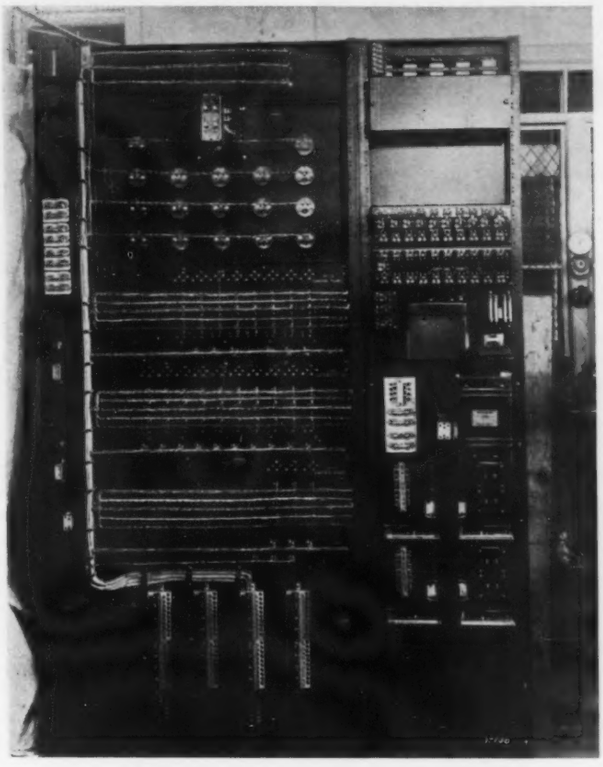

*Fig. 25. Rear view of miniature control panels.*

audible alarm. Should the breaker automatically reclose, the red lamp and audible alarm would be de-energized, but the white lamp would remain lighted. To de-energize these indicator lamps, a double-throw push-button switch is depressed, bringing in a green lamp. This push button is restored to normal and all lamps de-energize, when the trouble has been cleared at the distant substation.

### Conclusion

The economies in this type of control equipment were not fully realized at this substation, as has been stated, but in the design of future substations, an appreciable saving may be made over the equipment now in use, principally in the size of building and size of cables and in duct runs.

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## *Miniature Control at Inyokern Substation Southern Sierras Power Company**

Installation of motor-operated mechanisms on the four oil circuit breakers in the two main transmission tower line circuits at Inyokern, in connection with the inauguration of relay protection on these lines, made an ideal situation for the application of some miniature method of control. To keep all control and instrument transformer circuits to as short a length as possible, a standard duplex steel switch house was set up at a central point in the station yard. All motor-operated mechanism-control circuits, current and potential transformer circuits, route to this switch house by means of multi-conductor lead cables encased in treated wooden ducts. The switchboard, which completely fills this steel switch house, contains all protective relay equipment and the miniature control equipment.

The control equipment in this installation consists of standard telephone double-throw keys and indicating lamps. These telephone keys actuate auxiliary contactors, which serve to close or trip the oil circuit breakers in a manner conventional to motor-operated breaker equipment. These auxiliary relays are mounted on the same switchboard with the protective relay equipment.

The principal reason for considering miniature control equipment for this installation was that it was desired to control these oil circuit breakers from the operator's cottage, approximately 300 ft. distant. A small control panel is mounted conveniently in the operator's cottage. A standard multi-conductor paper-insulated telephone lead-covered cable, installed underground in a wooden duct, serves to parallel this board with the duplicate control equipment in the switch house previously mentioned. The control switch arrangement is exactly the same on both the cottage panel and the relay board, the grouping being in the form of a single-line diagram of the station. Small brass strips ¼-in. wide serve as dummy bus and suitable composition handle plugs complete the diagram effect by indicating air-break or disconnect switches. A "master" push-button type telephone key, located in the center of the panel, must be depressed simultaneously, while actuating any control key to the "trip" or "close" position to complete the control circuit. This master key also serves to energize the proper indicating lamps when depressed, the lamps being normally extinguished to prevent a constant current consumption.

This control system operates from a 36-volt storage battery. The installation has been in successful operation for a period of six months. The insulation of one of the two "master" keys gave some trouble at first, but it is felt that the cause of this trouble has been permanently remedied by removing the acid type storage battery from the compartment at the rear of the switchboard. Aside from this one feature, the entire installation has operated in a thoroughly satisfactory manner.

It is estimated that the control equipment, consisting of two sets of keys and lamp indicators and one set of auxiliary contactors, cost approximately three-fourths of what standard control switches and indicating lamp would have cost. The cost of the control circuit from the cottage to the switchhouse is estimated to have been approximately one-half of what it would have been with standard control circuit make-up.

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* By F. Ayres.

# *Metal Clad Switchgear**

*It has been the desire of the committee to give in this report a brief description of most of the types of metal clad gear commonly used, together with a few comments upon their adaptability to different classes of service. Following this is a more detailed description of several typical installations illustrative of the case. Statements from manufacturers conclude the report.*

METAL clad switchgear is not new on the coast, having been used for over five years. Its use has increased rapidly during the past two years, probably due to the fact that it is being more fully realized that the additional first cost is more than offset by the saving in installation costs, high salvage value, dependability, and long life.

Experience has shown that there is a material saving in its use and that the outdoor metal clad gear will withstand all kinds of weather, high winds, and heavy precipitation with a surprisingly low record of failure. It is predicted that within a few years the metal clad equipment will supersede most of the present design. As this equipment approaches a standard and the development charges are absorbed, the first cost will materially reduce, which will increase its popularity. Manufacturers report that their metal clad switchgear departments are crowded with work and that new designs are being developed and manufactured as rapidly as the central station needs are realized. Metal clad switchgear sales have increased steadily in volume, in the face of a decreasing market on other apparatus during the past two years.

There are three principle types of metal clad switchgear used by the Pacific Gas and Electric Company, commonly known as:

1. The truck type.
2. The elevating type.
3. The steel cell or cubicle.

### The New Truck Type

Metal clad switchgear of this type are used by this company in stations and substations of major importance where only a single bus or main bus and transfer bus is required. They are generally used on circuits of 11 kv. or 4 kv. Where a transfer bus is installed, only one truck unit is employed and the switching to the transfer bus is done by disconnects mounted in a superstructure over the truck unit. The control switches, meters, and relays are mounted on the steel panel, which constitutes the front of the removable truck element. Where the service rendered is sufficiently important to warrant purchasing a spare removable truck unit, if the circuits are of different ampere capacity, the spare truck unit must necessarily be of the highest ampere rating—for example, a transformer bank unit. If this unit is used as a spare for the feeder circuits, the calibration of the ammeters and relays will be incorrect as long as the spare unit is in use, due to the difference in current transformer ratios. If the transformer bank units have a capacity of 2,000 amp. or greater, the terminals of the spare unit will not fit in the 600-amp. feeder terminals. This will necessitate either purchasing two spare removable units or one spare for the feeder circuits only, and assuming that no spare unit will be required for the transformer bank circuits, as they are fewer in number and of greater capacity, and in consequence more rugged in construction.

In case of bushing failure or other causes which might produce an oil fire inside the truck, it is rather difficult to put the fire out, due to the inaccessibility of the different compartments separating the bus cells, switch cell and instrument and control compartments, etc. This condition does not exist with the elevating type, as in most cases everything except the bus and current transformer compartments is exposed and accessible.

The ventilation is better with the elevating type than it is with with the truck type.

In case of an oil or insulation fire, there is no doubt the elevating type structure is more accessible to fire extinguishing apparatus than the truck type, but it must be remembered that the tighter compartments in the truck will tend to prevent fire communication to adjacent units better than the more open elevating type.

The projected floor space required by the truck type is greater than that required by the elevating type and also a larger aisle room is necessary.

It is well known that a great advantage of both the truck and elevating type gear lies in the fact that all disconnecting switches are eliminated and, with them, the danger of opening them accidentally under load.

### The Elevating Type

Where a double bus is required, where floor space is at a premium, and where the control and instruments are mounted remote from the structure, the elevating type metal clad gear is very desirable. Almost any combination of switching units may be employed and, if necessary, bus spacers can be used to permit the installation of feeder reactors with a minimum of space required.

There are at present two methods employed for lowering the oil circuit breaker to the disconnect or test position and for removing the oil circuit breaker for inspection or other maintenance purposes. These will be briefly described as follows:

*Method No. 1—*

An elevating truck and inspection rack are furnished.

The truck consists of a platform on wheels which can be rolled from one switch to another. After the truck has been rolled under the oil circuit breaker, the platform is raised by means of a suitable winch, the oil circuit breaker is unlocked, and the unit lowered either to the disconnect position or the extreme lowered position ready for removal. If the oil circuit breaker is to be inspected or repaired, it is rolled to the inspection rack and raised into position, all by means of the truck.

*Method No. 2—*

A low platform truck on wheels, but without an elevating platform and winch is furnished, and instead of the elevating platform, a lowering and raising device is mounted on each individual metal clad unit. If the oil circuit breaker is to be entirely removed, the platform truck is inserted under the breaker and the unit is lowered onto it by means of the individual lowering device. The oil circuit breaker is then rolled to a conventient location and the tank removed by means of a small hoist. If the oil circuit breaker is to be lowered into the test or disconnect position, this is accomplished by means of the individual raising and lowering device without the use of the platform truck.

The individual device is slightly more expensive than a single elevating truck for the entire group of units. However, there is a distinct operating advantage in the individual device where there is a double bus and a large number of switches installed. Should it become necessary to clear a bus by disconnecting all the oil circuit breaker units, the use of one elevating truck would result in a lengthy and somewhat laborious undertaking. The advantage of the individual type is obvious.

The installation costs of both the truck and the elevating type are low, due to the fact that the units come tested, wired

* Report of subcommittee on metal clad switchgear, electrical apparatus committee, Engineering Section, R. B. Kellogg, chairman, B. Anderson, G. M. Babcock, A. Fulton, A. S. Glasgow, C. P. Gorman, P. C. McCorkle, R. B. Pollock, J. C. Rea, S. P. Russell, E. K. Sadler, R. C. Stackhouse.

and assembled, and all that is necessary for their installation is a suitable level foundation and the bolting together of the units and bus members. With the connection of the control and main cable, the complete group of units is ready for service.

### The Steel Cell or Cubicle

The steel cell is used in smaller stations for many auxiliary purposes, such as starting compensator cells, switch cells for motor generators, station service compartments, street lighting compartments, disconnecting switch and fuse compartments, etc.

One convenient form of steel cubicle containing bus, oil circuit breaker, disconnects, current transformers and cable terminal is as follows: The bus is mounted on suitable supports to the top compartment, the disconnects in a separate compartment below, and the current transformers, oil circuit breaker, and cable terminal in the bottom compartment. Considerable height is saved by mounting the oil circuit breaker on wheels and providing extra flexible cables to the terminals and suitable secondary disconnecting devices for the control leads. In this way, the oil circuit breaker may be readily disconnected and rolled out for inspection or repair.

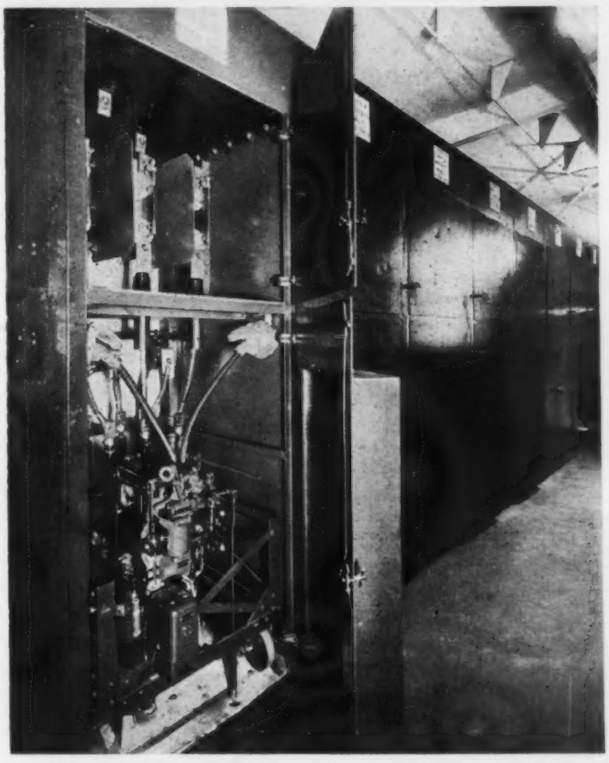

*Fig. 1. Typical 11-kv. steel cell built by the Pacific Gas and Electric Company. 11-kv, three-phase bus in top compartment, disconnects below. Oil circuit breaker mounted on wheels in bottom compartment, with flexible cable main connections and disconnecting couplers for control wires. Station N, Pacific Gas and Electric Company.*

Steel cubicles are widely used for outdoor country substations of from 500 to 5,000-kva. at 11 kv. and 4 kv. These cells contain complete equipment, including bus, disconnects, oil circuit breaker, cable terminal and switchboard, with necessary instruments and relays for automatic reclosing.

All three types of metal clad switching equipment have been used by the Pacific Gas and Electric Company for a number of years and no failures which can be traced to the metal clad construction have occurred.

The following constitutes a brief description of several installations typical of the different types of metal clad switchgear described above.

### Station "A", San Francisco

Truck type switches and metal clad lift-up switches are used for auxiliary service at Station "A", San Francisco.

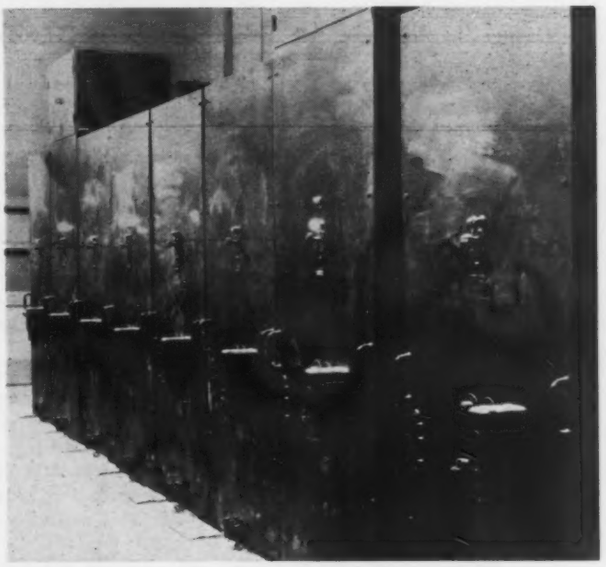

*Fig. 2. Seven truck type metal clad switchgear installed at Station A, Pacific Gas and Electric Company.*

The 11-kv., 3-phase auxiliary bus consists of seven truck type solenoid operated oil circuit breakers. There are four outgoing lines using 600-amp. oil switches and two incoming lines, and one bus tie using 800-amp. oil switches. These truck type switches are mounted against a wall with the cable leads coming up from below.

The assembled truck type switches form a single bus system, a split into two sections by a bus tie, each section being fed from the main 11-kv. bus through cables protected by reactors.

The trucks are totally inclosed and complete with current transformers, oil switches, and auxiliary relays. Potential transformers, resistors, oil switches, and auxiliary relays. Potential transformers, resistors and fuses are mounted in a separate steel cell on top of the truck inclosure. These cells have steel doors on the front to afford access for changing fuses.

*Fig. 3. Twenty-one truck type metal clad switchgear installed for auxiliary service at Station A, Pacific Gas and Electric Company.*

One emergency control switch with red and green lamp indication is mounted on each truck. The switchboard controlling the entire structure is located in the main switchboard room.

A 2,300-volt, 3-phase bus is installed for furnishing power to the auxiliary motors in the steam generating plant. This bus consists of twenty-one truck type units of which sixteen are 7,500-volt, 600-amp. oil circuit breakers for three incoming lines and two bus ties. These trucks are arranged as a single bus and are fed from three separate 11,000/2,300-volt transformer banks, each bank feeding one section, the sections being connected by bus ties. The feeder breakers are manually operated and the incoming lines and bus ties are solenoid operated. These truck type units are completely inclosed and are complete with current transformers, etc. Potential transformers are fused, protected by resistors, and mounted in separate cells on top of the trucks. Each truck has a hinged steel front panel, on which are mounted ammeters, relays, auxiliary relays, control switches, test blocks, etc. The back of the switchboard is isolated from the oil switch compartment by a vertical steel barrier. The hinged panel provides access to the wiring on the back of the panel.

A metal clad switch and bus structure, consisting of elevating type oil circuit breakers is installed in the pump house. The space allotted for switching equipment was so limited that truck type switches could not be installed. This structure consists of eleven units, of which nine contain oil switches and two disconnect switches and fuses for protecting the house service banks. This equipment constitutes a single bus system, which is separated into three sections. The incoming and outgoing lines are equipped with motor operated 600-amp., 7,500-volt oil circuit breakers and the bus ties with motor operated 800-amp., 7,500-volt oil circuit breakers. The cells are inclosed on the top, sides, and back, the front being open. The structure also contains the current transformers and cable potheads. The potential transformers are mounted in separate steel compartments on top of the cells. The switchboard, controlling the operation of the lift-up switchgear, is located in another part of the building.

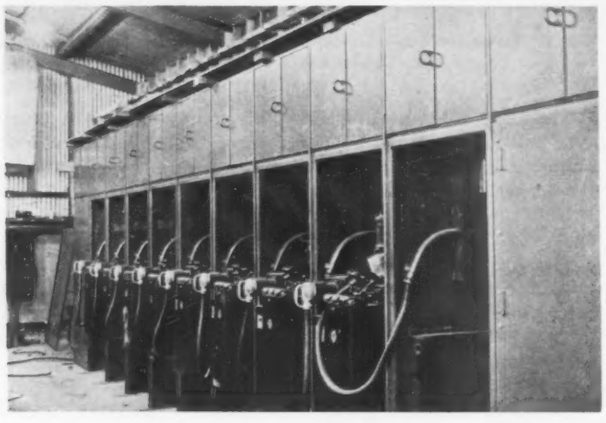

*Fig. 4. Eleven elevating type metal clad switchgear installed in the pump house, Station A, Pacific Gas and Electric Company.*

*Fig. 5. 11-kv. switchroom, Station D, Pacific Gas and Electric Company. At the left 11-kv. cells containing starting compensators and oil circuit breakers for motor generators. At the right 11-kv. bus, consisting of nine units metal clad switchgear, 15,000-volt oil circuit breakers, elevating type.*

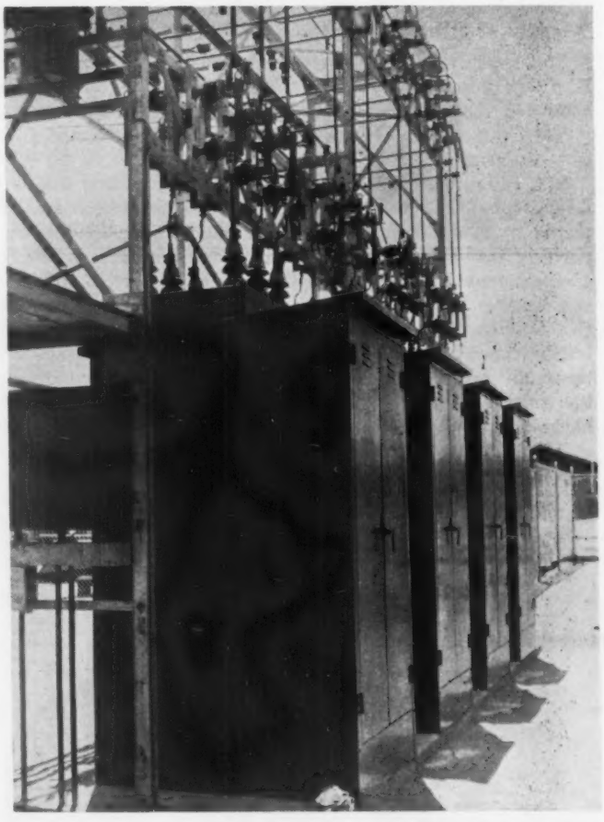

*Fig. 6. Victorville substation. One totaling and three distribution circuit roof bushing type switch houses.*

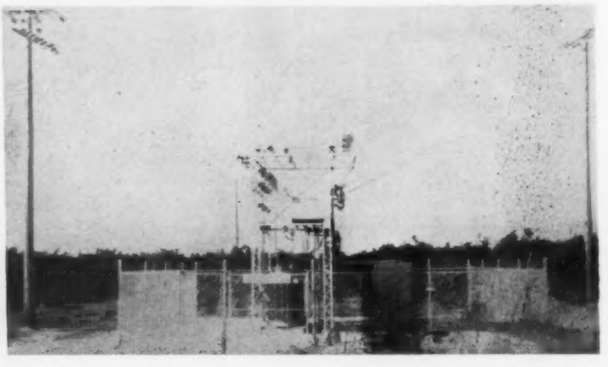

*Fig. 7. No. 2 substation, City of Redlands. View of rural substation showing two roof conduit type switch houses.*

### Station "D," San Francisco

Nine 15-kv. 600-amp., 3 P.S.T. metal clad units of the elevating type are installed in Station "D," San Francisco.

These units form a single bus in three sections and each section is composed of one incoming cable and one motor generator feeder cable. Two bus section units tie the three sections together.

The complete structure houses the main bus, current transformers, potential transformers, oil circuit breakers, and cable terminal. All apparatus is readily accessible.

The bus compartment, and potential and current transformers compartments are of the dry type and not oil or compound filled. The main bus bars are covered with Bakelite insulation.

### Southern Sierras Power Company

The Southern Sierras Power Company has found the outdoor type of substation to be most suited to its needs and has only made use of indoor substations in a few instances in recent years. In only one case have they used any of the indoor types of metal inclosed switchgear, this being in the Hemet substation.

In reconstructing this substation in 1926 seven truck type reclosing switchgears were installed, one being a spare unit. These trucks control 2,300-volt distribution circuits, with an average maximum load of 90 amp. each. The motor-operated reclosing equipment is supplied with 220-volt a.c. power. The units were originally installed with a single bus but this has proven unsatisfactory because of the interruption to service necessary when a truck is removed for maintenance or inspection. The installation of an auxiliary bus with transfer equipment is now being contemplated. The features in the design of these units which have been found objectionable have been largely eliminated in later design.

In our outdoor substations we have not found a situation where it would be necessary to concentrate heavy duty switchgear in a small space and have therefore made no installations of the elevating type outdoor metal clad switch-

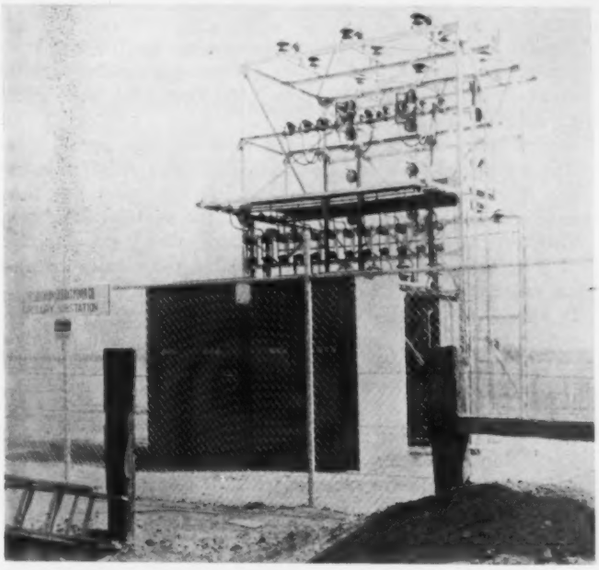

*Fig. 8. Gregory substation. This picture illustrates the use of two duplex roof conduit type steel switch houses to provide one totaling and three circuit compartments.*

ing equipment. We have, however, made a rather general use of steel switch houses. These are all in use on 2,300 or 4,000-volt distribution lines. The earlier installations were made with standard manufacturers' units but more recently all except reclosing units were assembled in our shops. The latter units have proven very satisfactory and economical and well adapted to the service requirements of our system.

The assembled units are so designed that they can be used for roof bushing, roof conduit, or floor conduit entrance or a combination of these. The accompanying photographs illustrate the way in which these entrances are made and also the interior arrangement. Standard switching and metering equipment is used in the assembly of these units.

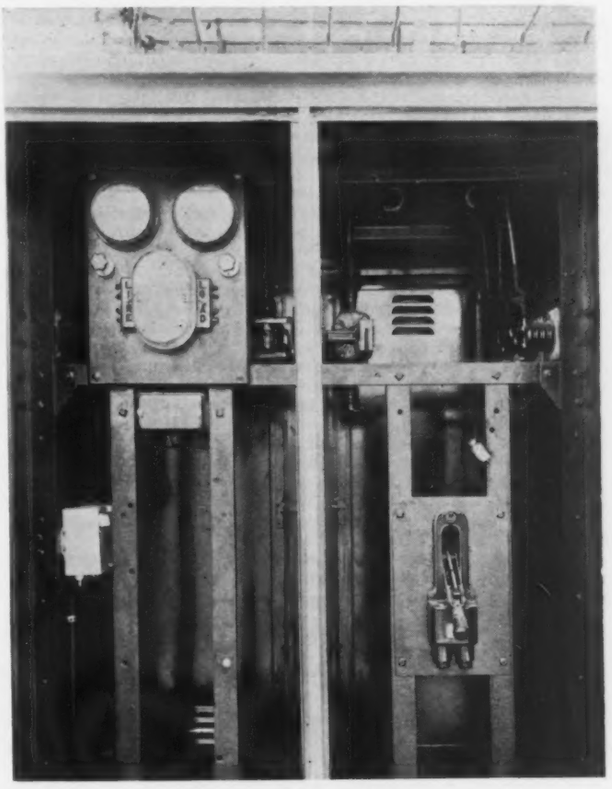

*Fig. 9. Gregory substation. Interior of duplex roof conduit type steel switch house which provides space for two sets of switchgear and metering equipment.*

They are made up in both single and duplex houses. In the past three years we have installed 54 single units and 5 duplex units. The following tabulation covers three typical substations where steel switch houses have been installed.

| Location— | San Bernardino | Victorville | Somerton |
|---|---|---|---|
| Service | Distribution | Distribution | Distribution |
| Voltage | 4,000 star | 2,300 delta | 4,000 star |
| Kva. per circuit | 200-350 | 100 | 250 |
| No. of circuits | 6 | 3 | 2 |
| Bus | Operating and auxiliary | Operating and auxiliary | Operating and auxiliary |
| Operation | Remote control solenoid | Manual | Motor reclosing |
| Control voltage | 125-volt d.c. | | 220-volt a.c. |

### Statement From Manufacturers

#### *General Electric Company*

In order to meet the requirements of operating companies throughout the country for various conditions of safety, economy and simplicity of operation, this company has developed and put into production a complete and comprehensive line of metal inclosed switching equipment, ranging from simple single unit outdoor switch houses to complete metal clad oil filled station layouts with oil circuit breakers for 138,000-volt service and 2,500,00-kva. interrupting duty.

The following tabulation will give the several classes of metal inclosed gear from which a selection may be made to fit the conditions attendant to each particular installation, the proper selection to be based upon a consideration of the

physical layout, economic condition and system of operation best suit to the job.

*Indoor Equipments*—For switching equipments located in power houses or substations, metal inclosed gear is subdivided into the following classes:

(*a*) Metal inclosed drawout units with air circuit breakers for low-voltage house lighting or power service.

(*b*) Metal inclosed cubicles for circuits up to and including 15,000 volts, having oil circuit breakers, instrument transformers, disconnecting switches and buses inclosed within a cell-like structure, with hinged doors and with a swinging front panel on which is mounted all control switches, instruments and relays. These units are completely self-contained and require a minimum of installation cost per feeder position.

(*c*) Truck type panels for circuits up to 15,000 volts, consisting of a stationary steel structure inclosing buses and connections, and transfer switch arrangements if desired, and having oil circuit breakers or high speed air circuit breakers together with instrument transformers mounted on a removable wheeled truck with a front panel for instruments, relays, and control.

(*d*) Truck type breaker equipments consisting of a stationary housing containing buses and selector switches, if desired, and breakers mounted in steel cells on wheels. These breakers are available for circuits up to 15,000 volts and with interrupting ratings up to 1,000,000 kva. The control, instrument and relay equipments are mounted remote on control panels.

(*e*) Metal clad or elevating type equipments, consisting of a stationary structure supporting totally inclosed buses and instrument transformers, and a removable element, consisting of an oil circuit breaker and its operating mechanism, which is raised up into position either by means of an elevating truck or by means of an individual elevating device forming part of each unit. These equipments are available for circuits up to 15,000 volts and with interrupting ratings from 65,000 to 500,000 kva.

Metal clad equipments, consisting of larger breaker units having three separate tanks, can be furnished for interrupting capacities up to 1,500,000 kva., and 23,000 volts.

*Outdoor Equipments*—For installations where substation buildings are not warranted, metal inclosed gear of the following classes are available:

(*a*) Outdoor switch houses with roof entrance bushings having oil circuit breakers and all control and metering equipment mounted completely within the housing. These equipments may be furnished for individual installation, or may be furnished in groups with busing and disconnecting switches either of the outdoor type or inclosed in superstructures joining the various housings.

(*b*) Outdoor cubicles similar to the indoor type, except arranged with the instrument panels within the structures and completely weatherproofed.

(*c*) Outdoor metal clad elevating type, with oil filled buses and compartments. These equipments are made in two general classes, the first consisting of an arrangement for breakers similar to those used with indoor metal clad equipments for services up to 34.5 kv. and 1,500,000 kva., and the second consisting of an arrangement for large outdoor type breakers from 46 kv. up to 138 kv. and 2,500,000 kva.

A type has recently been developed duplicating the medium capacity indoor metal clad with a weatherproof structure similar to switch house construction.

In considering the selection of the proper type of switching equipment to be used for any particular installation, the economics of the problem should include not only the first cost of the apparatus suitable for the operating conditions but also the cost of installation and maintenance as well as the insurance against plant shutdown and injury to operators.

Metal inclosed equipments were primarily conceived and designed to provide an increased measure of protection against shutdown and accident, to a varying degree depending upon the class of equipment as outlined above. In addition the inherent designs are such that most of the interconnection and assembly work is done on a unit basis in the manufacturer's works so that field work on the part of the operating companies has been reduced to a minimum.

*Westinghouse Electric & Manufacturing Company*—

Until five years ago there was very little metal inclosed switching equipment in use in the United States. Since that time the growth has been quite rapid. During the past year the development has been along the lines of simplification, standardization and modification, with the aim of shipping the apparatus from the factory as completely assembled as possible.

For installations using smaller breakers, the tendency is to employ indoor steel inclosed cubicles, since they are the cheapest and simplest form of factory assembled switchgear. They are suitable for breakers up to 350,000 kva. interrupting capacity and voltages of 15,000 and below. The principal installations involve auxiliary switching for steam power stations, distributing substations and industrial plants, such as paper mills, rubber factories, steel mills, etc.

Such cubicles can be arranged for single or double bus with disconnecting switches, the latter single-pole hook-stick operated or gang-operated and interlocked with breakers. The advantage of the cubicle type of construction, especially for industrial plants, is the saving in the installation time and high salvage value in case the equipment must be relocated at a later date. The combination of switchboard panels with the circuit breaker structure makes the unit self contained and eliminates conduit and cable runs between the switchboards and structure.

Outdoor switch houses, although a small portion of the metal inclosed switchgear family, are widely used throughout the country for distribution feeders and for controlling circuits on dredges, electric shovels, steel mills, oil field motors, etc. In general, they are used as individual units, although combination houses are made up to form a bus structure.

The number of new installations of removable truck-type switching equipments have decreased somewhat, although many companies, including steel mills, prefer this type of construction; their preference is on account of the greater convenience of disconnecting and interchanging circuit breaker units, with the corresponding decrease in the interruption time.

Truck-type units involving breakers up to 750,000 kva. interrupting capacity at 27,600 service voltage and with current carrying capacities up to 3,000 amp. have been used with satisfactory results.

Except with oil breakers of the smallest type, switchgear of the horizontal type costs more to build and requires more space than the metal clad vertical lift type and for this reason will probably be superseded by the vertical lift type.

The vertical lift type has become increasingly popular the past year and installations have included practically all applications for indoor switching equipment.

It offers the simplest arrangement of switchgear having a removable disconnecting type of breaker and one occupying the least space. A separate handling truck or carriage is used to handle the breaker unit and to put it into position.

During the past year the developments have been along the line of standardization and improved forms of insulation. The insulation on the conductors and buses is now pressed or molded on, with insulation at the joints either omitted (on 2,300 volts) or consisting either of cambric tape or poured insulation. The tendency has been very marked to omit filling compound up to 15 kv., as a result of preference by the operating engineers.

For indoor installations above 15 kv. and even for some installations at this voltage, metal clad switchgear of the oil-filled type has been employed so far, although the number of equipments have been comparatively small. Units of 500,000 kva. at 24 kv. have been furnished. The early installations of this oil filled type of switchgear were shipped approximately disassembled and without oil in place, necessitating considerable drying out and oil filtering in the field before equipment could be placed in service. In recent installations every effort has been made to ship the equipment as

complete as possible with oil, thus permitting a larger percentage of joints and connections being made at the factory, with corresponding decrease in installation time and expense.

The type of construction of the buses is somewhat similar to the outdoor oil-filled equipment, with the phases in individual pipe inclosures and the general design made to suit the different types of breakers employed.

Oil-filled type 15, 22, and 33-kv. outdoor equipment has become quite general during the past year. Comparatively recently the Chicago district has made such installations, and similar equipment for heavy capacity stations is being considered now for several Eastern cities. Developments during the past year in the outdoor oil filled equipment have been along the lines of standardizing on the ratings of the N.E.M.A. and N.E.L.A., and changing designs to reduce size to permit shipment of entire bays complete, factory assembled, oil filled. Such modifications work to the advantage of the manufacturer and the user in reducing the disassembly labor and time of the manufacturer, and the installation cost on the part of the customer. In the shipment to the Chicago district, a six-bay double-bus 33-kv. structure ready for connection to the cables required a total time of 153 man-days on the part of the customer. This time included the unloading of the equipment from cars, erecting and supporting columns and the stationary structure, raising the breaker units into position, making up the bus junction joints and completing the oil piping. The heaviest piece per bay to be handled weighed approximately 15 tons.

The No. 2 and No. 3 units of the State Line power station are being constructed along the same lines, with the idea of making complete factory assembled bay as a unit. This equipment involves breakers having an interrupting capacity of 2,500,000 kva. with a 3,000-amp. bus. The largest single piece to be handled will be approximately 30 tons, the service voltage of 22-kv. equipment being designed to withstand a test of 58 kv. at 60 cycles for one minute without oil and 85 kv. when completely oil filled. To check the sufficiency of the electrical and mechanical design, the equipment will receive 125,000-amp. momentary current from the high power testing laboratories before shipment is made.

One interesting development made in the equipment is in the application of the solder seal porcelain joint on the main contact insulators. The supporting flange, as well as the contact castings, is soldered direct to the porcelain insulator, thus simplifying the construction and eliminating two gasketed flange joints on each contact. The joint remains perfectly tight under high temperatures and high oil pressures, is not affected by a wide range of temperature and is mechanically stronger than porcelain itself. The oil test of the assembled insulator units is made at 70 lb. with oil at 9 deg. C., although the actual operating pressure is less than 10 lb.

The trend is not clear on higher voltages, although quotations have been made on 132-kv. oil filled switchgear equipment and one manufacturer is building an equipment at the present time for installation in the Chicago district. In all cases the design comprised a combination of circuit breakers and disconnecting switches, connected together by means of oil filled cable and potheads. However, at the present time there has been no operating experience with high voltage metal clad switchgear and it will be sometime before the tendency in this direction is clearly defined.

In conclusion we may state: Cubicles have come into extensive use and there will be increasing demand for their application especially in small substations and industrial plants.

The truck type switching equipment, particularly that of certain types of breakers, will probably continue to be used for them. Their use for oil circuit breakers is decreasing.

The use of indoor metal clad switchgear is increasing, the tendency being to omit the filling compound on lower voltage units and to use oil on the higher.

Outdoor metal clad oil filled switchgear for voltages up to 33 kv. has not yet received general approval for moderate and heavy capacity installations but its use is increasing.

*Condit Electrical Manufacturing Corporation—*

Many years ago this company originated a heavy duty truck type oil circuit breaker with a view to simplifying and speeding up servicing of breakers in use.

A desire to eliminate disconnecting switches led to the development of automatic disconnecting means, when it was desired to truck the breaker out of its cell. The addition of the closing relays to this housing was the next step, this being followed by complete metal clad truck type switchgear, the meters and auxiliary devices being carried on the front of the switch panel, later, on the swinging door inclosing a compartment in front of the switch operating mechanism.

The complete development may be included under the following headings:

*Metal Inclosed Switchboards*—With this construction the disconnects are inclosed in a separate housing above the switchboard. The switchgear may or may not be truck mounted, each pole being provided with its own separate trucks.

This switch truck was later provided with a collapsible link which could be closed by means of a screw mechanism to lift the breaker up into position, connecting it to the bus bars and control circuits, the latter being so arranged that contact was made with them before the main bus connection was made, permitting testing the switch in this position "B" before it was connected to the bus bars in position "A."

*Metal Inclosed Draw-out Switchboard*—With this construction the switchgear and draw-out disconnecting switches are inclosed in truck mounted steel frames. This frame carries the closing relay, auxiliary switch, current and potential transformers, and reclosing relays when these are desired. The switchboard proper may or may not be a part of this structure.

*Truck Type Steel Cubicles*—In this construction each switch cell is an entirely inclosed steel cubicle, the front consisting of a hinged door on which are mounted meters, relays, etc., the wiring on the rear of the door terminating through a flexible connection to a terminal block on the interior of the cubicle. This is manufactured in a number of standard forms to suit any condition of bus arrangement. It is also made with stationary panels, access to the breaker being from the rear of the board.

Outdoor steel inclosed switchgear has been developed somewhat along the lines described above, metering devices, etc., being carried in steel inclosures in the breaker supporting structure.

*Allis-Chalmers Manufacturing Company—*

During the past year, the attention of our engineers has been directed to improving our standard lines of horizontal drawout armorclad switchgear in details of design. All of our standard circuit breakers were redesigned to incorporate the most modern features of design, particularly those affecting operating mechanisms and the venting arrangements on the breakers. The new design of circuit breaker has been proved on test to provide greater margin of safety on rated interrupting capacity than heretofore. The operating mechanisms have been put through grueling tests to insure ruggedness and infallible reliability.

Preliminary designs have been made for armorclad switchgear of the outdoor type of switchgear in all ratings up to and including that voltage.

# *Operating and Maintenance Methods**

*A study of the reports submitted indicates wide divergences of practice with respect to all the subjects. For that reason, and due to the variety of subjects included, a general summary is not possible, but the reports received are briefed by subjects, in the following paragraphs.*

THE program of work as outlined for this committee included the following subjects:

1. Inspection of equipment
2. Organization of operating and maintenance crews
3. Tools
4. Loading of transformer and feeder apparatus
5. Protection of potential transformers
6. Utilization of salvaged apparatus.

## Inspection of Equipment

*Oil Circuit Breakers—*

The method of arbitrarily assigning a certain number of equivalent normal openings between major inspections or overhauls is evidently spreading and may now be said to be the commonest practice. In this method, each violent opening or kickout is rated in terms of normal or non-violent openings, and the number of equivalnet normal openings at any time is the sum of the normal openings plus the violent openings rated in terms of normal openings. When the breaker has reached its assigned value of equivalent normal openings, it is thoroughly overhauled. In addition, some companies make periodic tests of the oil in breakers and one company meggers all its major breakers every three to six months. This check is made from bushing to bushing with the breaker open, and from bushing to ground with the breaker closed. Some companies still have no very definite method of determining when major overhauls are necessary, but seem to rely entirely on the judgment of the maintenance man or operator. One company overhauls after fifteen kickouts, or earlier if there is any indication of trouble.

Considerable variance is found in the routine inspection of breaker mechanisms. Some companies make such an inspection monthly on all major station breakers, while others do so every three to six months. However, the increasing importance of such regular inspections has been conclusively shown by one company, where an analysis of one year's operation of relays indicated that of the total number of cases of trouble not properly cleared, field equipment was responsible for 45 per cent, and in by far the largest number of these cases, the breakers or pallet switches on the breakers were at fault. This company is adopting the practice of checking the opening time and the timing between phases with a cycle counter after each overhaul. Where the highly sensitive carrier current pilot protection is used, this is particularly necessary. For example, in one case it was found that the opening of a breaker on a line during normal switching set up residual currents of a frequency of from 300 to 1,500 cycles, sufficient to cause the carrier protection on another line to lock out, and that the condition is very much accentuated where all three phases of the breaker do not open very nearly simultaneously. As one company report states: "The necessity of routine or regular inspection is based on the experience that deferred maintenance is often costly and that an ounce of prevention is worth a pound of cure."

All companies use some form of written report for major overhauls, but routine mechanism inspection reports are not in general use, and where used are solely for station records.

*Transformers—*

Regular periodic overhauls of transformers are not standard practice. Periodic routine external inspections are general practice, the frequency varying from once a month to once every six months. One company makes an internal inspection annually on all large station transformers and every two years on all small station transformers, such inspection consisting of lowering and filtering the oil, checking all connections and leads, repairing of leaks and a careful inspection of the winding. Some companies make a practice of routing all transformers taken out of service through the repair shop for inspection and general overhaul before they are sent out again. This practice has proven very advantageous in locating trouble which could be caught in no other way, and preventing breakdowns.

One company meggers all large transformers semi-annually and all small ones annually.

Written reports are usually made on major overhauls, but regular forms are not always used. Routine inspections are reported on regular forms in one or two cases.

*Feeder Voltage Regulators—*

Only one company makes a regular annual inspection of regulators, and filters the oil in them every two years. The general practice seems to be merely the regular cleaning and oiling done by the operator or by a maintenance man, who makes weekly or semi-monthly visits to the unattended stations. One company has found it advantageous completely to overhaul a regulator whenever it is moved from one location to another. The only regular form is one used by the company making a regular annual inspection.

*Buses and Disconnect Switches—*

Inspections of this equipment are apparently confined to routine inspections made by station attendants with one or two exceptions. One company makes a practice of thoroughly going over all heavy buses on condensers and generators annually, and of cleaning and lubricating disconnect switches from time to time when they are out of service.

*Cooling Towers—*

The frequency of inspection and cleaning varies with the location, amount of dirt, and condition of the water in the pond. It is the general practice to make periodic tests of the hardness of the water where water softeners are installed. A complete change of water in the pond seems advisable where softeners are used, due to evaporation eventually leaving the water supersaturated with soft salts. The frequency of such a change will of course depend entirely on local conditions.

*Cranes, Cables and Heavy Tackle at Stations—*

No general practice is followed with respect to inspections of this equipment. It would seem that immediately before and after any special heavy job a rather thorough inspection would be advisable, and this seems to be a more or less general practice.

*Miscellaneous Equipment—*

Two companies overhaul all synchronous condensers annually, such overhaul consisting of cleaning, varnishing windings, and inspection and cleaning of bearings. One of them meggers the machines at this time and the other one meggers them twice a year.

One company having surface coolers under some of its synchronous condensers for cooling the circulating air, has found it advisable to clean out the tubes of these coolers with compressed air once a year. In this connection, con-

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* Report of subcommittee on operating and maintenance methods, electrical apparatus committee, Engineering Section. J. D. Enefer, chairman, I. W. Collins, E. H. Cox, F. Curtis, R. C. Denny, D. Hall, D. J. Kelly, G. A. Riley, A. P. Sessions, D. D. Smalley, C. W. Smith, J. F. Spease.

siderable care must be exercised or the men doing the work will become seriously ill as a result of the vapors or gases blown out of the tubes, an ordinary exhaust fan in the pit under the machine being insufficient, as was found on the first attempt at cleaning. In order to conduct these noxious vapours and gases away, a special hood was put on in place of the head on one end of the cooler, and connected through stove pipe to an exhaust fan, which in turn exhausts through more stove pipe to the outside of the building. Compressed air is then blown through each tube from the other end of the cooler. This has given satisfactory results, and protects the workmen from the gases or vapors.

### Organization of Operating and Maintenance Crews

A wide divergence of practice is found in the organization of the operating and maintenance crews. In general the different organizations may be divided into two groups. In one group the operating personnel is distinct from the maintenance personnel, all maintenance work except very minor repairs being done by traveling maintenance crews, with the exception of the large stations, where one or two maintenance men are usually stationed to take care of minor repairs. The operating personnel have nothing to do with the maintenance work. Both the station operating foremen and maintenance foremen report to the same division operating superintendent. In the second group, the station chief or chief operator is in full charge of the station and all maintenance work is done under his supervision except at the very small one-man stations. Traveling maintenance men do most of the major repair work, except at the large stations, but are assisted by the operating crew, and frequently such jobs as oil circuit breaker overhauling are done by the station crew alone. At the large stations a permanent crew of from two to four maintenance men, under the jurisdiction of the station chief, do all the maintenance work, even including the overhaul of machines and transformers, painting of buildings and equipment, and some additions to or changes of existing equipment. All station chiefs and traveling maintenance men report to a division superintendent of substations, and he will at times temporarily move maintenance men from one major station to another to assist in major jobs. Members of the operating crew may be called on to do maintenance work as necessary. One company of the latter group also has recently assigned a test man to each division to work under the substation division superintendent's supervision and in conjunction with the maintenance men to take care of all testing, except acceptance tests of major equipment and machine or transformer dryouts.

No attempt was made to analyze the relative advantages of the two systems, as insufficient data were available. It is interesting to note that gardeners, and in some instances, landscape foremen, are now found on the payroll of practically every company, indicating that more attention is being given to the appearance of the grounds around the stations.

There is a marked tendency on the larger systems toward decentralization of dispatching, switching centers being set up at strategic stations and the operators taking over the dispatching of the lines and smaller stations for a certain section of the system. This relieves the central dispatcher of all routine and almost all trouble switching and makes that organization more a load and system dispatching organization, although it still retains authority over the switching centers and has final authority on all switching questions. This method has been found to expedite greatly the restoration of service during trouble and, from a psychological standpoint, adds interest to the work of the operators at the switching centers and makes for a more contented personnel.

### Tools

The only special tools reported were: a device for grounding the bottom terminals of back or bottom-connected type FH breakers, a recording apparatus to record the comparative make and break of contacts in certain high voltage breakers (See Electrical World of January 25, 1930, page 207 for detailed description), a motor-operated portable tank lifter for use on oil circuit breakers, using a ½-hp. three-phase motor mounted on wheels and properly geared down to a socket which fits the shaft end of the regular tank lifting device, a portable motor-operated device for operating certain gang-operated 220-kv. disconnect switches, a special portable motor-operated air compressor mounted on an air receiver, used for small air tools and capable of operating two pressure paint guns; special tools developed for cleaning bushings and insulators on the lower voltages while they are energized, and gas analyzers for use on inertaire transformers. Special tools are generally kept at strategic locations such as the headquarters of maintenance men, except those for the large stations, which are generally kept at the stations. Some small tools are generally supplied to all stations.

All companies except one require their maintenance men to furnish their own hand tools, such as pliers, hammers, screw drivers, rules, hack saw frames, and small crescent wrenches. One company, however, requires them to furnish only a pair of pliers. One company requires its assistant operators to have their own screw driver, hammer and pliers.

### Loading of Transformer and Feeder Apparatus

The general practice seems to be to use the ampere rating as the load limit for transformers and regulators, even though the oil temperature may be below the generally accepted safe limits of 70 deg. C. for water-cooled transformers and 80 deg. C. for air-cooled transformers. Possibly the effect of continuous overloading on the manufacturer's guarantee has something to do with this attitude, as there seems to be no hesitancy about overloading in emergency, as long as the oil temperature stays within the above limits. There is, however, a growing tendency on the part of at least some of the companies to make the oil temperature the determining factor. One company permits loading to give a 55 deg. C. rise. If the transformer on test showed a rise of approximately 55 deg. C., then the name plate rating is used, but if not, a somewhat greater load is permitted, depending on what the rise at full load actually was on test. The manufacturing companies generally recommend not exceeding the name plate ampere rating, pointing out the difficulty of accurately determining the hottest spot temperature by exploring coils and the advisability of having a margin for safety.

The ampere load is generally the determining factor in the loading of cables, regulators, feeder switches, current transformers, and other feeder apparatus.

The margin of spare transformer capacity allowed will depend entirely on the location, nature of the load, probable future growth in load and the size of the transformer. At the largest stations, with transformers of 10,000 kva. per unit or larger, the spare capacity runs as high as 100 per cent on the original installation. For example, one company reports 50 to 100 per cent in growing territory, such as factory locations, depending on the size of the station. At smaller stations the determining factor must necessarily be economic. That is, whether it is more economical to install smaller units and replace them in one or two years, or put in larger units to start with and pay the additional carrying charges. When replacements are made, the size of the new transformers will depend on what equipment, if any, is available on the system, or the next standard rating that can be purchased, as well as the projected load growth

in the surrounding territory. It seems to be generally conceded to be good practice to keep the spare capacity during normal peak load at approximately 15 per cent to 25 per cent.

Another important factor is the importance of the load being carried. For example, one company usually keeps two banks at important stations, either one of which can carry the peak load in emergency. Another company installs originally one bank and a spare. When the load reaches 75 per cent of the bank capacity, two more units are ordered to make a second bank. When the two banks become 75 per cent loaded, a spare is ordered and so on.

The determination of future transformer requirements is handled in different ways, but the original request usually emanates from the field and is then passed on by a distribution planning committee, system planning committee, or some similar committee. Upon final approval by the management, the transformers are ordered, usually by one individual, and scheduled so as to arrive in time to meet programmed installation dates. One company has a distribution planning committee composed of representatives of the distribution, substation and operating engineers departments. A careful study of the load growth is made, and an investigation made to determine what additional transformer capacity is necessary and what can be taken care of by rearranging load or lines. Recommendations of this committee are then passed on to the system planning committee, which consists of representatives from the operating, construction and engineering departments, where all requirements are incorporated into a final plan, including an operating date for each transformer, which is then submitted to the management for financial approval. Major station transformer requirements are determined directly by the system planning committee.

### Protection of Potential Transformers

There is a wide variance of practice with respect to the fusing of potential transformers, with a tendency toward the elimination of some of the fuses previously considered necessary. Summarizing the results from four companies reporting, three of them use no high tension fuses on 66-kv. and higher potential transformers, while one company does. All four use secondary fuses. On voltages between 11 kv. and 33 kv. inclusive, two out of six use no high tension fuses; three use them, and one company uses them only on buses or where the intervening automatic breaker between the transformer and the bus would kill the supply to the station if it relayed. Five of the six companies use secondary fuses while the sixth one does not. On voltages up to 6,600 volts, out of six companies reporting, four of them use no fuses on the high tension side on feeders; three use fuses on bus potential transformers only; one does not use any fuses, and one company uses fuses on all potential transformers. Four of the six use secondary fuses and the other two do not. It is thus seen that there is no standard, although the companies are more nearly in accord with respect to potential transformers of 66-kv. and higher voltages. It would be of interest to obtain from the various companies the data on which they have based their present practices.

### Utilization of Salvaged Apparatus

The proper utilization of salvaged apparatus requires co-ordinated study and co-operation on the part of members of the operating and engineering departments. The age of the equipment, its possible life if installed, the cost of any changes it may be necessary to make to it or to other equipment or to plans, if it is to be used, as against the depreciation write-off, if it is junked, are the main factors which must be considered. Another important factor, sometimes overlooked, is the cost of maintaining it, as against the maintenance cost for new equipment. It will sometimes be found that spare parts are either difficult to secure or relatively expensive. The operator must be willing to bury his natural disinclination to install second-hand equipment and the engineer must be willing sometimes to disarrange a nice looking plan, if salvage equipment is to be economically used. On the other hand, care must be taken that a large stock of salvage material which will never be used is not allowed to accumulate. One company has a materials committee composed of representatives from various departments. Slow moving and salvage material is brought to the attention of this committee and some member usually volunteers to see that it is disposed of; he is then held responsible for this being done. If no one knows of any use for a piece of apparatus, it is junked. A man known as the material engineer keeps in touch with all apparatus in stock. Before any new job is started, the designers send out a list of major material, which is checked with that on hand. The materials committee has the authority to enforce the use of salvage material, unless the intended user can show very good reason why its use would be impractical. The office of the chief engineer approves and enforces the use of large pieces of salvage equipment.

# FOREIGN SYSTEMS CO-ORDINATION COMMITTEE REPORTS[1]

## *Inductive Co-ordination of the Southern Sierras Power Company Hoover Dam Transmission Line**

*With the awarding of a contract to the Southern Sierras Power Company by the government for the furnishing of power required in the construction of Hoover Dam, it became necessary to plan for the construction of a high voltage transmission line between San Bernardino and Boulder Canyon. The line will also later be used to transmit the block of power generated at the Hoover Dam hydro-electric project, which has been allocated to the Southern Sierras Power Company. While the line will be constructed for 132 kv., it will be operated at 88 kv. during the period that power is furnished for the construction of the dam.*

*From the preliminary inspections for suitable routes for this line, it became evident that there existed a prob-*

* Written for the inductive co-ordination subcommittee, foreign systems co-ordination committee, Engineering Section. E. Y. Porter, chairman. K. B. Ayres, F. D. Beardsley, J. O. Binney, E. D. Brown, A. W. Copley, H. H. Cox, T. J. Fleming, W. F. Grimes, O. A. Gustafson, H. N. Kalb, H. S. Lane, E. R. Northmore, Stanley Rapp, M. A. Sawyer, J. F. Spease.

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California Independent Telephone Association: T. J. Fleming.
General Electric Company: O. A. Gustafson, J. F. Spease.
Los Angeles Bureau of Power & Light: I. L. Bateman, H. H. Cox, O. W. Holden.
Los Angeles Gas and Electric Corporation: C. B. Judson, E. R. Northmore.
Pacific Gas and Electric Company: C. C. Campbell, L. J. Corbett, R. R. Cowles, H. S. Lane, A. Scott.
Pacific Radio Trades Association: G. H. Curtiss.
The Pacific Telephone & Telegraph Company: D. I. Cone, Stanley Rapp.
Radio & Music Trades Association of Southern California: G. R. Walters.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow.
San Joaquin Light & Power Corporation: H. N. Kalb.
Sierra Pacific Power Company: E. D. Brown.
Southern California Edison Company Ltd.: R. B. Ashbrook, J. O. Binney, R. G. Boyles.
Southern California Telephone Company: M. A. Sawyer.
The Southern Sierras Power Company: C. M. Lindsley, E. Y. Porter.
Westinghouse Electric & Manufacturing Company: A. W. Copley, W. F. Grimes.

*lem of inductive co-ordination, due to the presence of the Southern California Telephone Company's San Bernardino-Las Vegas toll lines along the major portion of the tentative route. The co-operative work that was carried out in selecting a location for the transmission line which would be satisfactory from an inductive co-ordination standpoint is briefly outlined in this report.*

DURING the latter part of 1930, the Southern California Telephone Company completed construction of a toll line between San Bernardino and the Utah state line northeast of Las Vegas, which extends to Salt Lake City, where connection is made to the existing transcontinental toll system. This lead, which is constructed on a private right-of-way, is designed for an ultimate of six crossarms of 8-in. spaced non-phantom carrier telephone circuits and will form an important link in the transcontinental toll system. The recently developed K-8 non-phantom transposition design is employed, permitting an ultimate of 24 carrier telephone systems and 33 voice frequency circuits, or a total of 105 telephone circuits, if the present three-channel carrier systems are employed.

Prior to the starting of construction of this lead in 1928, the route tentatively selected was checked with the power companies to ascertain if there were plans for transmission lines which might become involved in inductive exposures at a later date. While several power companies at that time expected to extend transmission lines through this general territory, in the event that the Boulder Canyon hydro-electric project was consummated, no plans of definite routes were available. The route was, therefore, laid out on as direct a line as practicable, considering the topography of the section and items of construction and maintenance accessibility and costs. Where the narrow valleys were encountered, an effort was made to route the line consistently along one side of the valley, so that a route with maximum separation and minimum number of crossings would be left available, should a transmission line be constructed at some later time. While this procedure involved added line length and constructing in locations less desirable from a construction and maintenance standpoint, in some cases, it has already proved of value in the selection of a route for The Southern Sierras Power Company's line.

In the very early stages of planning a route for a transmission line to Hoover Dam, the telephone company was advised of the tentative plans, and the various co-ordination features were informally discussed. Right-of-way maps of the toll lead, together with a strip map showing the more general location of the lead, were furnished to the power company. These maps were found to be of considerable benefit in both the reconnaissance and final survey work. Following the reconnaissance survey, a joint inspection of the proposed route was made by the power and telephone company engineers in order that a mutual understanding of the conditions involved might be obtained. While this inspection was confined mainly to the very general routing, several situations where it appeared difficult to secure greater separation were investigated in more detail.

As in the case of the toll lead, it was desirable to route the transmission line in as direct a line as possible, to minimize its length and to avoid as far as possible locations where initial construction and future maintenance would be difficult as well as expensive. With the toll lead occupying in some cases the most direct location and the section to be traversed consisting of mountains, desert and much rough territory, it was not a simple matter to select a route which would provide satisfactory separation from the toll lead.

After the reconnaissance survey was completed, a preliminary survey of the route was made by triangulation and maps were prepared by the power company on a 5,000-ft. per inch scale, showing the location of the tentative route with respect to the toll lead. These maps provided a very satisfactory exposure chart, from which calculations of inductive coupling could be readily made.

With the survey data available, together with preliminary calculations of the inductive coupling, a second joint inspection trip was made, in order to investigate more closely several sections of relatively close separation, as well as to study further certain angling exposures at crossings. It was found possible, by slight changes in the original survey, to obtain greater separation in most cases and to effect the crossings at somewhat greater angles at neutral points in the telephone transposition scheme. While these changes were in general of a minor nature, they each involved some additional expense on the part of the power company, which was directly chargeable to co-ordination.

In co-ordinating the line, it was necessary to consider the possible effects of induction from two sources: namely, normal power operating conditions, and fault current at times of short circuits to ground, commonly termed low frequency induction. Separations which are sufficient ordinarily to preclude appreciable induction under normal operating conditions of the power line, are generally not sufficient, where long exposures are involved, to avoid excessive low frequency induction at time of faults. The separations that will obtain between the toll lead and the route finally selected will be such that it is not expected that harmful induction will be experienced under normal operating conditions of the power line.

The approximate lengths and separations for the route finally selected are as follows:

| Length of Exposure (Miles) | Separation (Feet) |
|---|---|
| 6.0 | Less than 2,000 |
| 26.4 | Between 2,000 and 4,000 |
| 29.8 | Between 4,000 and 5,000 |
| 61.0 | Between 5,000 and 10,000 |
| 123.2 | Total less than 10,000 |

In addition to the above, there is approximately 65 miles of exposure at a separation greater than 10,000 ft., which is still within the limits of influence from a low frequency induction standpoint. This makes a total of 188 miles of exposure, out of a total power line length of approximately 224 miles within limits requiring consideration.

It is not possible to determine accurately, except by test, the voltage which will be induced in the telephone circuits at times of fault to ground in the power line, because the value of earth conductivity is generally not known. The following calculations were, however, made for the section between Victor substation and Hoover Dam, using two assumed values of ground conductivity.

| Ground Conductivity | Induced Voltage Per Amp. of Fault Current |
|---|---|
| 10-14 | 13.7 |
| 10-13 | 3.6 |

The fault current for the condition of a zero resistance short circuit to ground at the Hoover Dam end of the power line is estimated as 80 amp., hence with a ground conductivity of 10-14, the total voltage will be 1,096 volts, while a ground conductivity of 10-13, will result in a total voltage of 288. No data are available as to the probable ground conductivity in this section, but it is believed that a value somewhere between 10-14 and 10-13 will exist. Tests will, therefore, need to be made to determine accurately the overall coupling.

These estimated values of induced voltage indicate that, even with the large separation obtained, it may be necessary to provide means of limiting the fault current under the initial operating arrangement of supplying power from San Bernardino. Later, when power is received from Boulder Canyon and the voltage is increased, the matter of induction

from fault current will again need to be reviewed to determine the fault current conditions which will obtain under the new operating arrangement.

In order to obtain line balance and to co-ordinate more effectively the closer separation parallels, the power company plans to install a total of 26 transposition barrels in the line. The barrels are to be of the halting type, of an average length of approximately 8.5 miles, with all transpositions rolled in the same direction. A study was made of the various types of transposition barrels, such as the halting, continuous and halting reverse, from which it was concluded that the halting type should be satisfactory. While there were some advantages to be gained by the use of the other types for some sections, it was felt that the added expense and increased construction difficulties were not warranted. The barrel will be somewhat shorter than the maximum lengths permitted by General Order No. 52.

In conclusion, it should be stated that throughout the planning of this project, as in the case of other similar projects, a fine spirit of co-operation has been evidenced. Both utilities have worked together closely on all phases of the work and have endeavored to handle the project in a manner which will produce results that will be mutually satisfactory.

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## *Development Tests and Performance of the Serjdetour Telephone Protector**

*To provide a protective device for power company telephone lines which will limit the voltage to ground to 1,700 volts and the between-wire voltage to 600 volts, which will not be blown to pieces by the discharge resulting from a direct contact between a telephone and power line and at the same time will be capable of carrying the currents occasioned by induced surges arising from power system troubles without becoming short circuited, a device was developed which has been called the "Serjdetour."*

POWER company telephone lines differ from commercial telephone lines in that the commercial lines are built as far distant from power circuits as is practicable, while the power company's telephone lines, in the majority of cases, closely follow the power lines and are therefore subject to inductive interference to a far greater degree than the commercial lines.

The protective scheme to be discussed here has been designed with the object of maintaining service through interruptions of moderate values, or to make immediate resumption of service after a severe case of trouble. As high current capacity has not been a requirement in commercial system protective equipment, it has not been obtainable from manufacturers of telephone supplies. Design and construction of considerable new apparatus has therefore been necessary.

The equipment on the line switching panel and the rubber insulated lead covered lead-in cable will withstand a potential of 1,700 volts to ground, while the bells, relays and insulating transformers have been tested and found capable of withstanding 600 volts between wires. Thus it is required that our protective device positively limit the voltage to ground to 1,700 volts and the between-wire voltage to 600 volts.

This protection must be provided and, at the same time, the equipment should not be blown to pieces by the discharge resulting from direct contact between a telephone line and a power line; also the device should be capable of carrying the currents occasioned by induced surges arising from power system troubles without becoming internally short-circuited. As these requirements are not met by any commercially available protective gaps, it was necessary to develop a device to fill the need. After a great deal of experimentation there resulted a device which has been named the "Serjdetour."

The Serjdetour is capable of sustaining the discharge occasioned by contact between a telephone line and power line, with no damage other than the welding together of the electrodes. When this occurs, it is only necessary to loosen four screws, remove the pitted electrodes, and substitute new ones. The device is then ready for service again. The pitted electrodes can readily be resurfaced in the shop.

While direct contacts between telephone and power lines occur occasionally, the great majority of disturbances consist simply of induced voltages to ground or between wires, due to exposure to power circuits under fault conditions. The discharge currents resulting from such induced voltages are much more moderate in value than those resulting from direct contact or lightning, and the Serjdetour is capable of handling these without becoming internally short-circuited.

This is an extremely valuable attribute, as it means continuity of communication service despite power system troubles. It has been determined by experiments that the current in our telephone lines during a power system fault will seldom exceed 25 amp., so in many installations 25-amp. fuses are placed in the line. For the great majority of disturbances the fuses will then not be affected. The Serjdetour will carry the discharge for the duration of the power system trouble without becoming short-circuited. In the few cases where the current exceeds 25 amp., the fuses will blow before there is any danger of the Serjdetour gap becoming short-circuited, except in the case of a direct cross, where it would not be reasonable to expect the gap to remain open. There is ample margin of safety here, as a Serjdetour, set to break down at 1,700 volts to ground, will carry 50 amp. for several minutes without becoming short-circuited. If set to break down at 600 volts, it will carry 20 amp. for a like time.

### Construction

The construction of the Serjdetour is extremely simple. In its most commonly used form, each unit consists of a group of three gaps, designed to be connected from each wire to ground and between wires, respectively. Each gap consists of a pair of cylindrical copper electrodes clamped in 3-in. steel cubes. (See Fig. 1.) The faces of these cubes are machined and are held parallel by a pyrex glass ring separator. This springs the faces of the electrodes into perfect parallelism, and the spacing between them is readily adjustable. The electrodes are tipped with pure rolled silver, ¼ in. thick, so that it is the silver which actually forms the arcing surfaces. The silver faces are machined with the greatest care to be perfectly flat, except for a slight beveling at the edges.

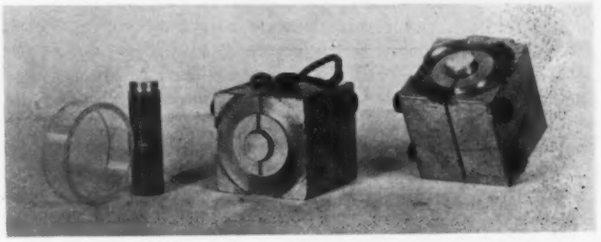


*Fig. 1. The component parts of a Serjdetour gap, showing the pyrex glass spacing ring, the silver tipped copper electrode and the electrode mounted in its heat absorbing block.*

* Written by R. B. Ashbrook for the power communication systems subcommittee, foreign systems co-ordination committee, Engineering Section. R. B. Ashbrook, chairman. I. L. Bateman, F. D. Beardsley, E. D. Brown, A. W. Copley, A. S. Glasgow, W. F. Grimes, O. A. Gustafson, O. W. Holden, C. B. Judson, H. N. Kalb, H. S. Lane, C. M. Lindsley, A. Scott, J. F. Spease.

They are given a mirror-like polish by the use of rouge. The success of the arrester action depends on the perfect parallelism of the faces and the smoothness of their surfaces. When these conditions are fulfilled, the arc spreads uniformly over the entire surface of each electrode face, and so has no tendency to concentrate at one place and build up a projection. It is also essential that the silver faces be backed by the larger copper electrodes and the massive metal blocks, as this insures that the heat be conducted away from the surface and absorbed in the blocks, thus avoiding undue melting of the silver.

The Serjdetour is, of course, not in itself a complete protective measure, but is the foundation unit upon which the protective system is built. To meet the requirements of the typical circuit the Serjdetour combination of Fig. 2 has

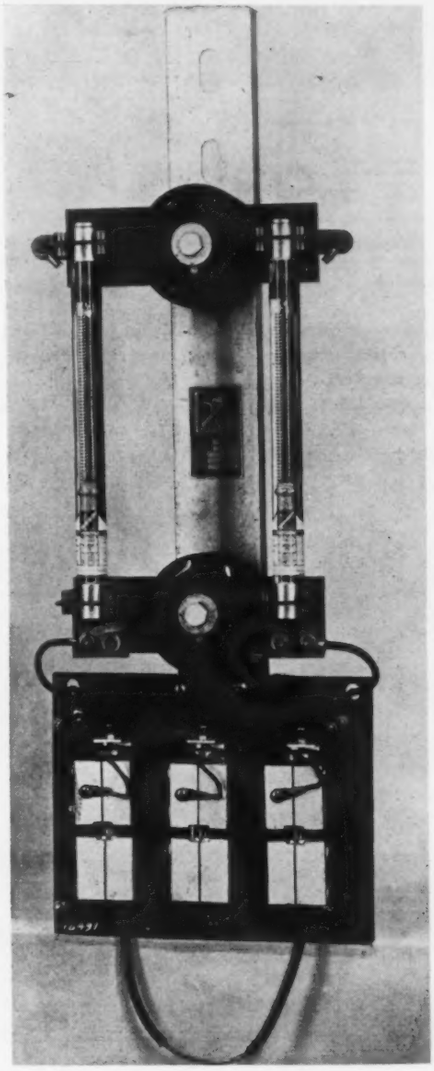


*Fig. 2. The Serjdetour protective unit showing the 25-ampere 25,000-volt arc quenching fuses and the Serjdetour arrester (cover removed.)*

been assembled. This consists of two gaps, set for 1,700 volts and one gap set for 600 volts. The unit is combined with the 25-amp., 25,000-volt arc-quenching fuses to form a protector unit for such installations. Ahead of this unit, horn gaps are installed.

In case of contact between the telephone line and the power line, the 25-amp. 25,000-volt fuses on the line side of the Serjdetour will open and an arc will start at the horn gap arrester located on an adjacent pole, thus eliminating any tendency for flashovers on the terminal pole. An independent ground for the horn gaps is used in places where it is impracticable to connect to the substation ground network because, should a ground connection be common to the horn gaps and the Serjdetour and not connected to the station ground, current might flow across the horn gaps, the common ground connection, across the Serjdetour gaps and thence, through inside telephone equipment, to the station ground after the fuses had opened.

A tendency, due to economy of operation, has been toward unattended substations on power distribution systems. This has made necessary a reliable means of indicating at an attended station the operation of circuit breakers at the unattended station. The use of the telephone lines for a reliable simplex alarm circuit has been made possible by the use of large capacity fuses and the positive action of the Serjdetour.

The simplex circuit is derived through the use of two impedance coils, insulated for 2,200 volts to ground and connected from each of the line wires through a suitable filter to the alarm equipment.

In some instances it is desirable to bypass the simplex alarm circuit from a telephone line built jointly with a power transmission line to a class "C" unexposed telephone line occupying pin positions on a foreign communication lead. Tests were made to verify the ability of the Serjdetour to protect the equipment under direct contact between the power and telephone lines, and also to investigate the use of a low pass filter as a simplex bypass around an insulating transformer.

### Test Line

In order to reproduce actual field conditions, a section of telephone line, including terminal equipment, was erected in proximity to a 66,000-volt power line, and a conductor allowed to drop from the latter into the telephone wires. This was done twice. In both cases, oscillograms were taken of the voltage to ground on the instrument side of the Serjdetour arrester and also on the output end of the filter. In Fig. 3 is shown a diagram of the test connections. It should be noted that the 66,000-volt line was tied into the Southern California Edison system through a 60,000-kva. power bank at Laguna Bell substation, and had also a 50,000-kva. condenser connected to it at that point. Thus the energy flow involved in the test was as heavy as that occurring during any accidental contact of telephone with power lines. Figs. 4 and 5 show the voltage, current, and kva. conditions at Laguna Bell during the two tests.

The protective equipment on the terminal poles included a horn gap on one pole, and the unit consisting of Serjdetour and two arc-quenching fuses on a subsequent pole. Between the horn gap and the Serjdetour was a current transformer to give an oscillographic record of the current in the Serjdetour.

### Results of Tests

The protective value of the Serjdetour was clearly demonstrated by the results of the tests. In both cases the equipment on the instrument side of the Serjdetour was undamaged—this, despite the fact that the impedance coils used in the filter were insulated for only 2,200 volts to ground, and the condensers were rated 1,700 volts d.c. The electrodes of the Serjdetour were fused together by the 1,000-amp. fault current, which, of course, was anticipated. Fig. 6 shows the condition of the electrodes after one test. It should be noted that the conductor that dropped from the power line into the telephone line was so arranged as to swing into one wire first, and probably did not carry into the other until shortly before the fault was cleared by the oil switches. This accounts for the heavy fusing on the right-hand electrodes and the very light pitting on the other two.

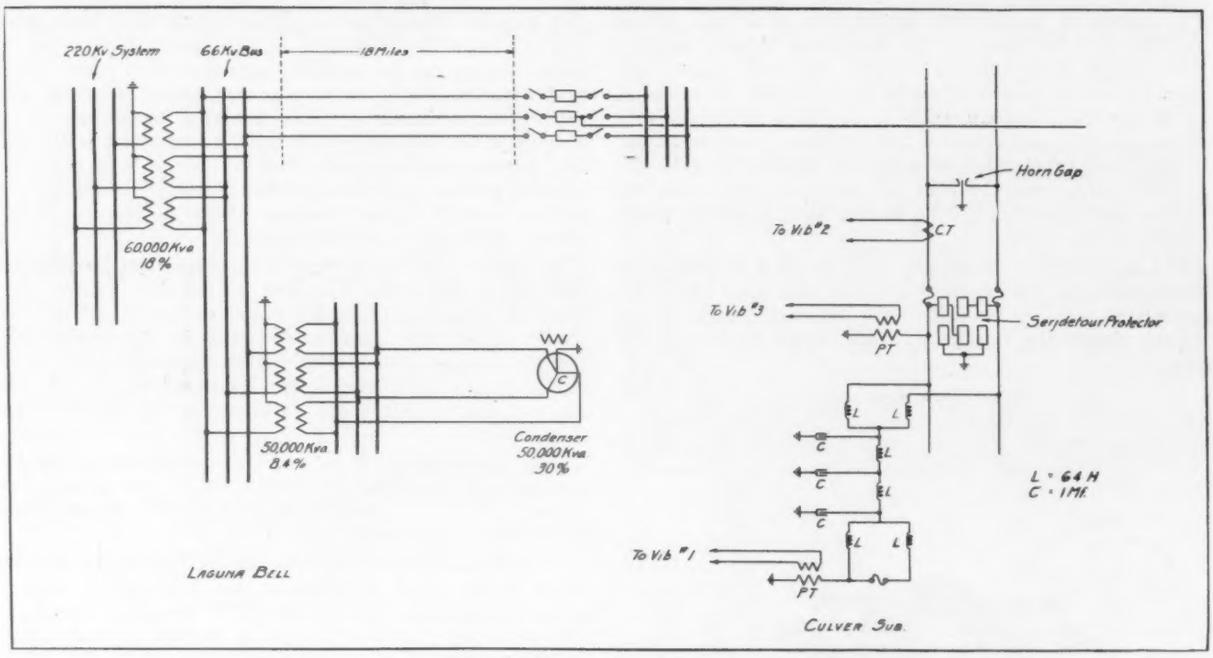
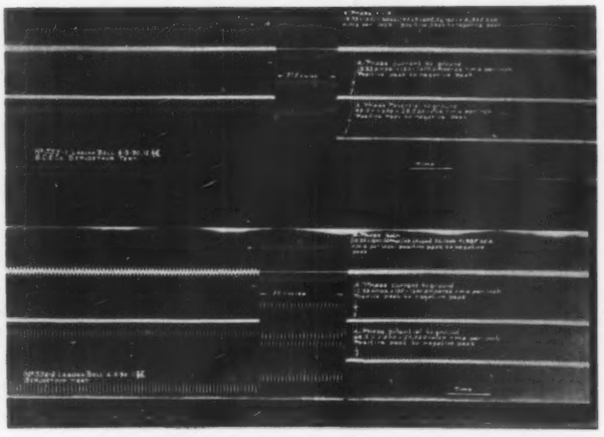



*Fig. 3. Diagram of test connections.*

In order to restore the protector to operating condition after the first test, it would only have been necessary to replace the electrodes and fuses. However, in order to preserve all the specimens for later study, the second test was made with a complete new installation of horn gap, Serjdetour, and fuses. Figure 7 shows the condition of the horn gap after one test.

Fig. 8 was taken during the fault. The large flash near the center of the picture is the horn gap, and the smaller arc to the left of it is the contact between the 66,000-volt conductor and the telephone wires. At the right of the picture is seen the blowing of the fuses on the Serjdetour protector unit.

The oscillograms of the two tests are shown in Figs. 9 and 10. In Fig. 9 there is just one very short swing of current, showing that the fuses blew with great rapidity. There is no observable voltage swing on No. 3 vibrator, which was immediately on the instrument side of the Serjdetour, but



*Figs. 4 and 5. Showing voltage, current and kva. conditions at Laguna Bell during the two tests.*

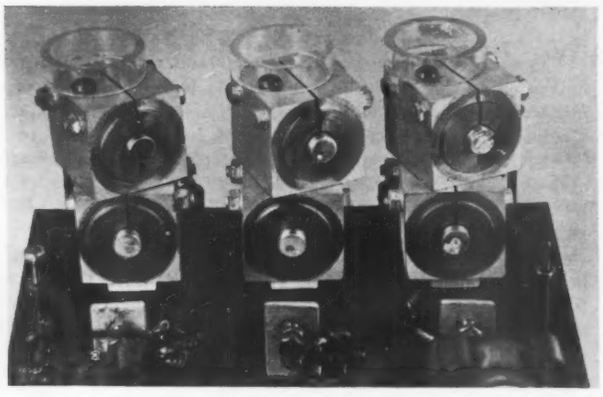


*Fig. 6. The Serjdetour arrester after one test.*

*Fig. 7. The horn gap used in one of the tests.*

there is an instantaneous kick of 4,650 volts on the output end of the filter, coincident with the cessation of current flow. This may be due to some transient phenomenon arising from the discharge of the condensers when the fuses blow, or it may be a reflected wave initiated by the voltage

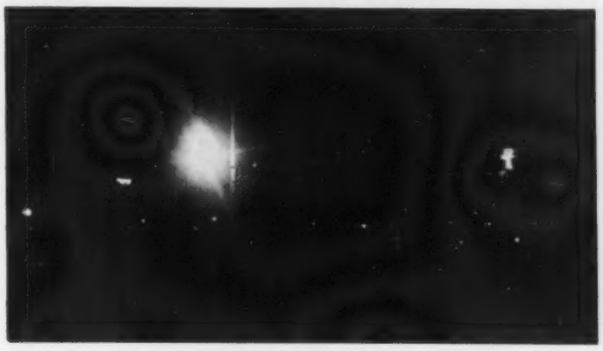
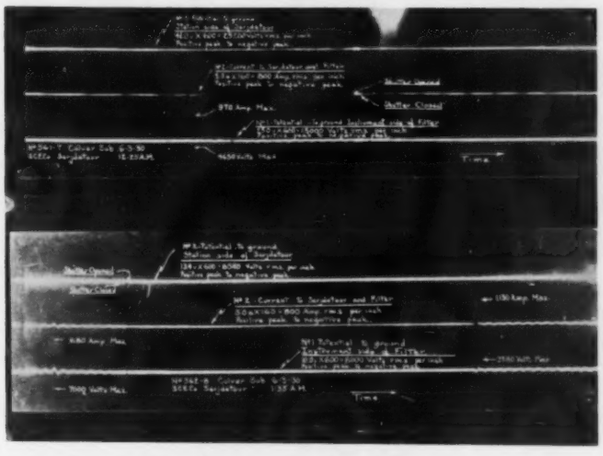


*Fig 8. Photograph taken during the test.*

impressed on the filter in the few micro-seconds it takes the Serjdetour gap to break down. This voltage does not exist long enough to affect the solid insulation of the apparatus or to cause the oscillograph vibrator to respond, but still it must be there for an instant and so start a wave travelling down the filter. This wave may be reflected several times at the open output end and also at the input end, which is dead, short circuited by the fusing of the gap. Thus it may build to a transient of sufficient magnitude and duration to cause the oscillograph vibrator to respond.

The magnitude of the voltage impressed on the filter in the few micro-seconds before the gap breaks down is probably not over 2,500 volts, the instantaneous d.c. breakdown of the gap, because supplementary tests made later show



*Figs. 9 and 10. Oscillograms taken during the two tests.*

that, with 50-cycle voltage, the rate of build-up is so low that the voltage does not have the opportunity to go above the breakdown voltage of the Serjdetour gap.

Fig. 10 is the oscillogram taken on the second test. It will be noted that the calibrations of both voltage vibrators were made more sensitive in this test—nevertheless, no voltage appeared on the No. 3 vibrator ahead of the filter. The instantaneous kick at the output end of the filter was repeated. In addition, at the extreme left of the oscillogram, is seen a 7,000-volt kick which apparently accompanied an instantaneous surge of current, occurring shortly before the fault was cleared by the main circuit breakers. A moving picture record of the test disclosed the fact that this current surge was exactly coincident with a very quick extinction and restriking of the arc at the point of contact with the 66,000-volt conductor, probably due to the latter swinging into the second telephone wire.

The oscillograms show that the Serjdetour protects the equipment beyond it from voltage, at least of any magnitude or duration discernible by the string oscillograph. They do indicate a phenomenon occurring in the filter whereby a voltage kick of extremely short duration appears at the output end. Since this voltage is in the nature of a static kick and can have no power behind it, because of the choking of the filter impedance coils, it can readily be taken care of by a small arrester of the ordinary commercial type, set to break down at about 300 volts.

The foregoing tests indicate that the Serjdetour has made possible a protective system which not only prevents damage to valuable equipment in stations for the extreme case of actual contact between telephone lines and power lines, but also preserves continuity of communication service after power system disturbances which create surges of considerable magnitude on inductively exposed telephone lines.

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## *Power Company Telephone Line Protection**

*The fundamental purpose of all protective equipment on telephone circuits is to prevent injury to the station equipment and the user in case excessive voltages are impressed on the telephone line, either by induction during normal or power system fault conditions or by actual contact between power and telephone lines. The requirements for adequate protection are especially severe on the considerable proportion of power company telephone lines which are constructed under power lines, particularly of the higher voltages, and the standard devices available for use on ordinary communication company circuits are quite inadequate to meet them. Special devices designed to meet this situation have therefore been developed by both the manufacturers and the operating companies.*

*Beyond this fundamental purpose, the different operating companies have developed special requirements, depending upon each company's usage of its communication circuits and operating practices, which have resulted in the development of widely different designs and arrangements of devices to suit their several needs. This paper will therefore be confined to a discussion of the equipment and practices of one company.*

THE Pacific Gas and Electric Company owns and operates something over four thousand miles of open wire telephone circuits, approximately half of which are constructed on distribution or transmission lines of more than 11 kv. The induced voltage to ground on telephone lines under transmission circuits varies from the order of less than 100 volts, on those circuits constructed or reconstructed in accordance with the present day standards, to 5,000 volts on a portion of the older lines which have not been so reconstructed. The problem of protection therefore varies from the requirements of Class C or "cold" lines, on routes separate from the power lines, to those for very "hot" lines.

For lines classed, from the standpoint of protection, as "cold," that is, not subject to linear exposure to lines in excess of 5,000 volts, the company uses a standard telephone station protector, comprising ½-amp. wood fuses with saw-

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* Written by H. S. Lane for the subcommittee on power company communication systems, foreign systems co-ordination committee, Engineering Section.

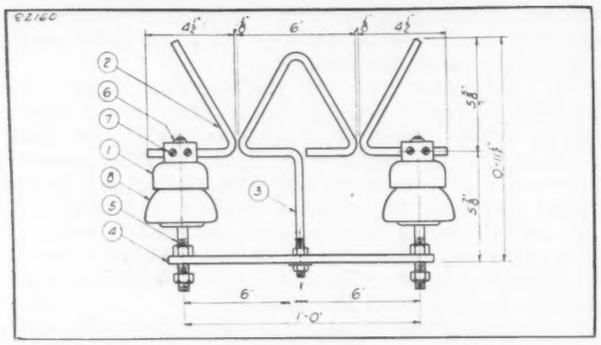

*Fig. 1. Assembly of horn gap lightning arrester for telephone lines.*

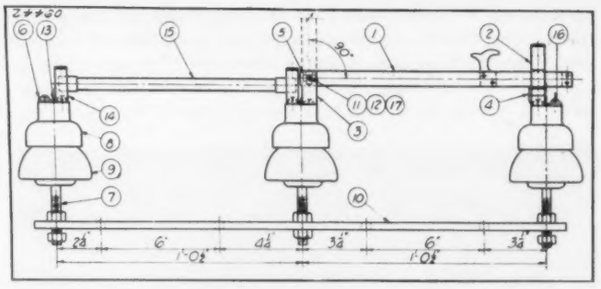

*Fig. 2. Assembly of outdoor type S.P.S.T. disconnecting switch and fuse for telephone lines.*

tooth gaps, usually mounted in a weatherproof porcelain box with cover for outdoor mounting. The sawtooth gap has been selected in preference to the more usual mica gap type, because our experience indicates that the former is less troublesome in service, being substantially self cleaning under ordinary fault conditions, therefore causing fewer interruptions and requiring less maintenance. This item is of considerable importance, in view of the many installations on our lines in relatively isolated locations not under supervision of trained telephone maintenance men. The standard gap setting for such arresters is 15 miles.

### Hot Line Protection

For protection of stations connected to "hot" lines, the company has designed equipment to meet the severe requirements encountered, comprising, in the order named, horn

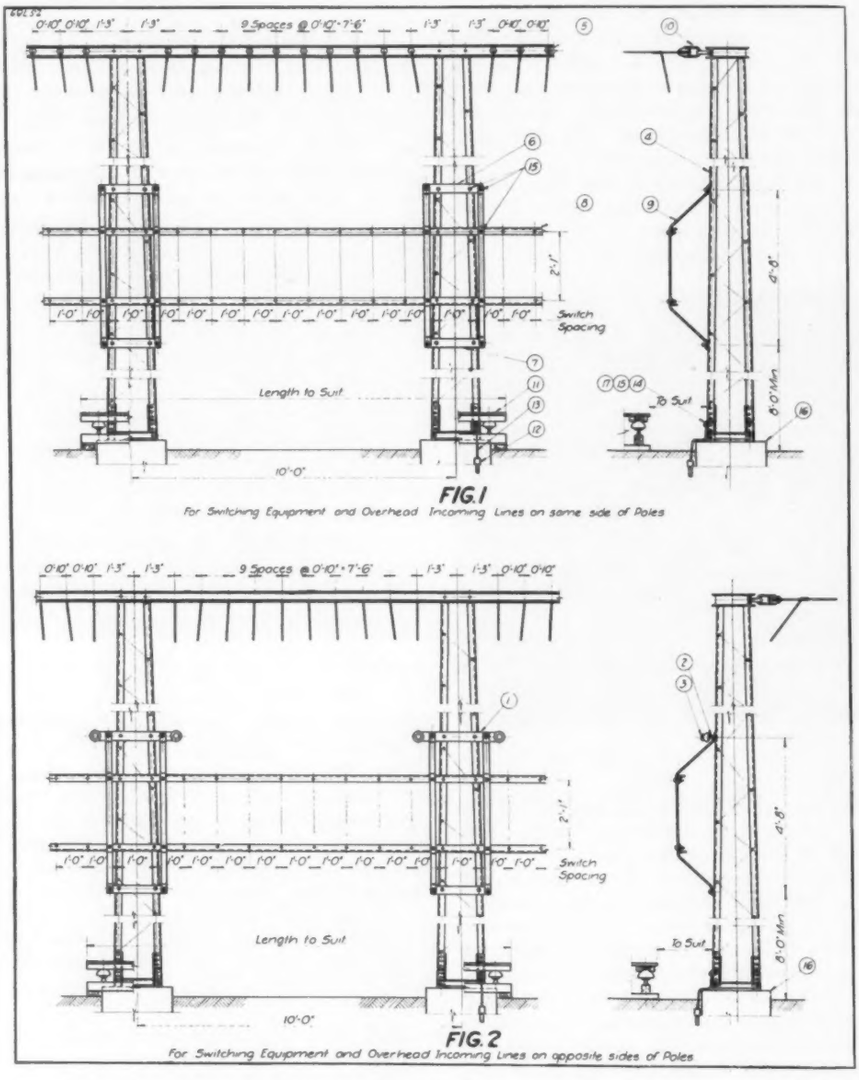
9 Spaces @ 0'-10" + 7'-6"
Switch Spacing
Length to Suit
10'-0"
To Suit
FIG. 1
For Switching Equipment and Overhead Incoming Lines on same side of Poles
9 Spaces @ 0'-10" + 7'-6"
Switch Spacing
Length to Suit
10'-0"
To Suit
FIG. 2
For Switching Equipment and Overhead Incoming Lines on opposite sides of Poles

*Fig. 3. Requirements for double latticed pole structures for supporting outdoor telephone equipment.*

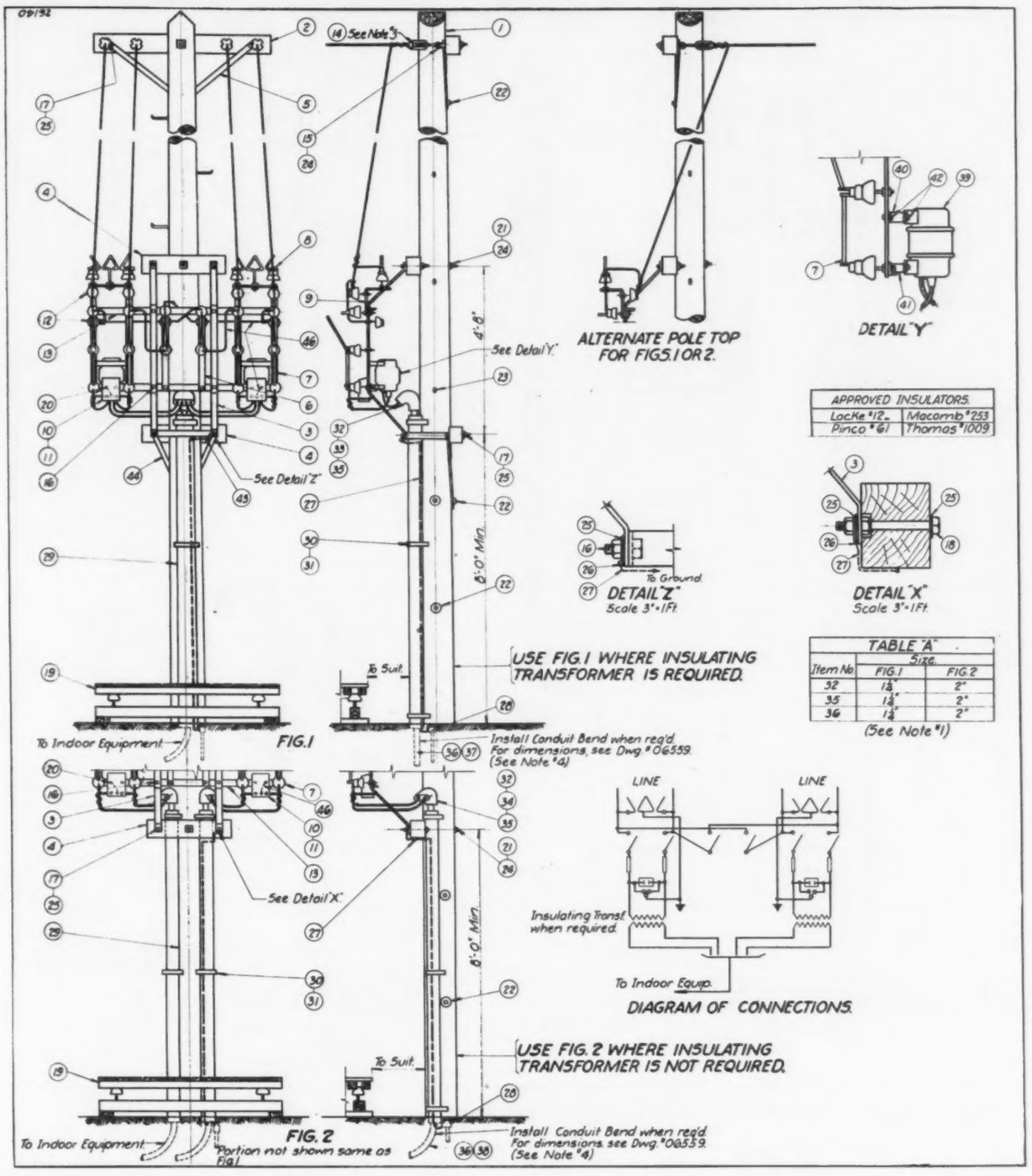


*Fig. 4. Arrangement of wood pole telphone structure for single circuit loop station with protective equipment on both sides of loop.*

gap (Fig. 1), fused switch (Fig. 2) using ½-amp. fuse, and combined vacuum and air gap arrester mounted in a weather proof cover. This equipment is mounted on standard racks, on either latticed steel or wood poles, according to circumstances of installation. Incidentally, single-throw and double-throw disconnecting switches designed to mount on the same structures are available to provide for bypass and switching arrangements as required. The methods of mounting these units of equipment are illustrated in Fig. 3, showing a double latticed pole structure. The details of a typical wood pole structure are shown in Fig. 4. A typical installation at patrolman's test or switching station with telephone instrument installed in a box on pole is shown in Fig. 5.

At every station where it is practicable to do so, an insulated stool or platform is used in connection with wall-set and associated switches mounted on vertical panels, so as to avoid the necessity for insulating transformers, with their attendant losses. An incidental measure of safety in this connection is the use of a dead front cam lever type of switch, designed by the company, with ample clearance and insulation to meet the requirements of this type of service. This switch is shown in Fig. 6.

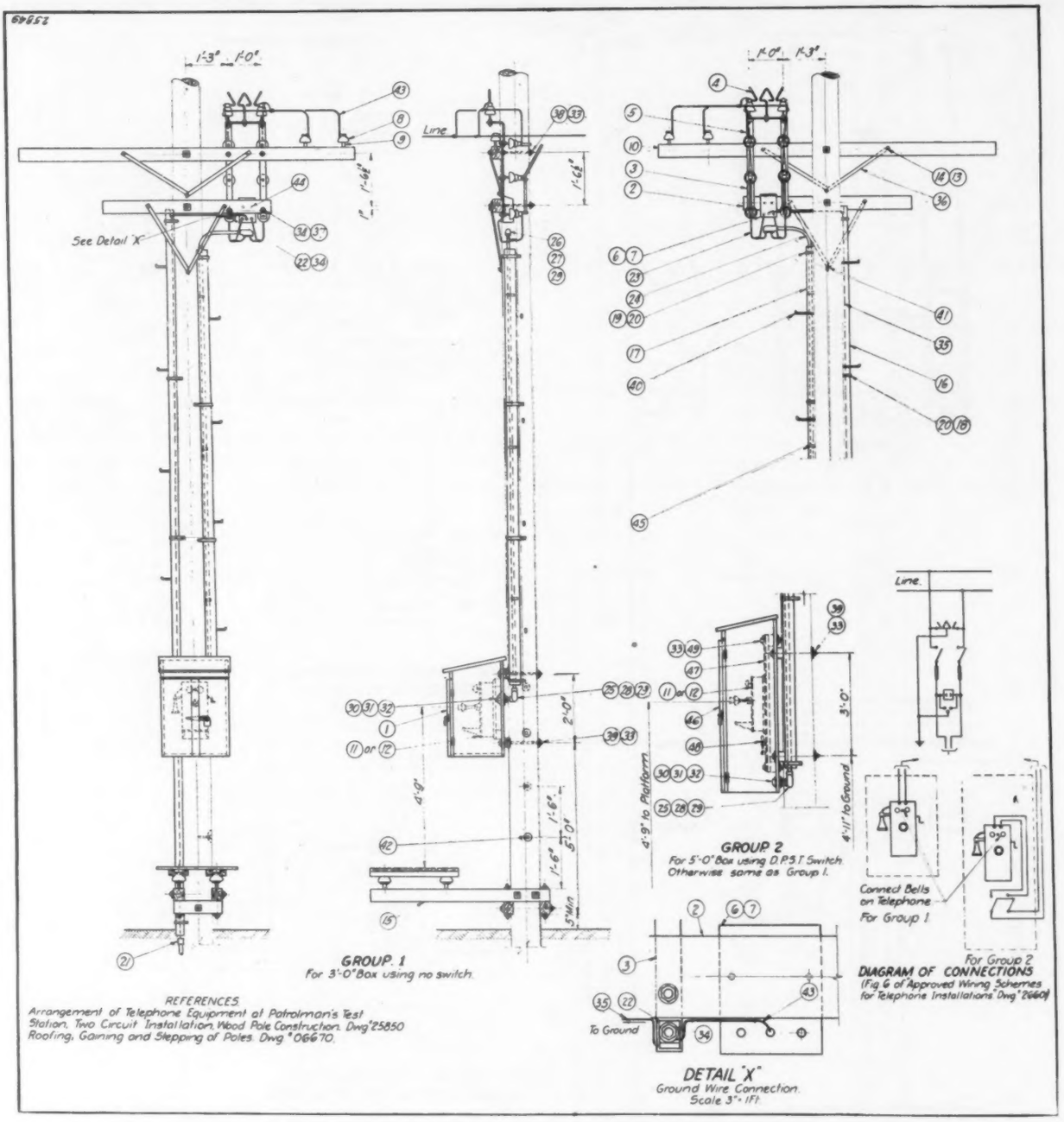
See Detail 'X'
Line
GROUP 1
For 3'-0" Box using no switch.
GROUP 2
For 5'-0" Box using D.P.S.T. Switch.
Otherwise same as Group 1.
4'-9" to Platform
4'-11" to Ground
Connect Bells on Telephone For Group 1
For Group 2
DIAGRAM OF CONNECTIONS
(Fig. 6 of Approved Wiring Schemes for Telephone Installations" Dwg. "26601)
To Ground
DETAIL "X"
Ground Wire Connection.
Scale 3" = 1'-0"
REFERENCES.
Arrangement of Telephone Equipment at Patrolman's Test Station, Two Circuit Installation, Wood Pole Construction. Dwg. "25850
Roofing, Gaining and Stepping of Poles. Dwg. "06670.

*Fig. 5. Arrangement of telephone equipment at patrolman's test station, single-circuit installation, wood pole construction.*

Where it is not practicable or desirable to use the insulated stool, an insulating transformer is installed in each circuit entering the station, mounted on the protection rack as illustrated in the drawings. We consider that the insulating transformer serves only the same function as the insulated stool, namely protection from voltage between line and ground. At stations where the line is looped in and ordinarily cut straight through, but may be sectionalized, particularly where the transmission line may be sectionalized, an arrangement is used permitting the line to be closed through by means of the bypass switch ahead of all protection, leaving the switch in one drop open, thereby avoiding the interposition of any fuses or transformers in the through line and providing one spare set of protection ready for instant use, but furnishing access to both sections of the line through full protection, when sectionalized for any reason.

The standard setting for the knurled gaps in the vacuum and air gap arresters is 15 mils, for the horn gaps 50 mils. With these settings and adequate ground connections, the equipment described has shown a high degree of efficacy, even under the most severe conditions of contact between transmission and telephone circuits. Too much emphasis cannot be placed upon the necessity of obtaining adequate ground connections. The customary practice is to connect the telephone ground wire to the station ground network.

### Drainage Coil

At a number of locations on certain of the circuits which still have unduly high voltages to ground, and at other stations on normally hot lines where transformers would ordinarily be required, particularly where long circuits must be frequently connected together for through conversations

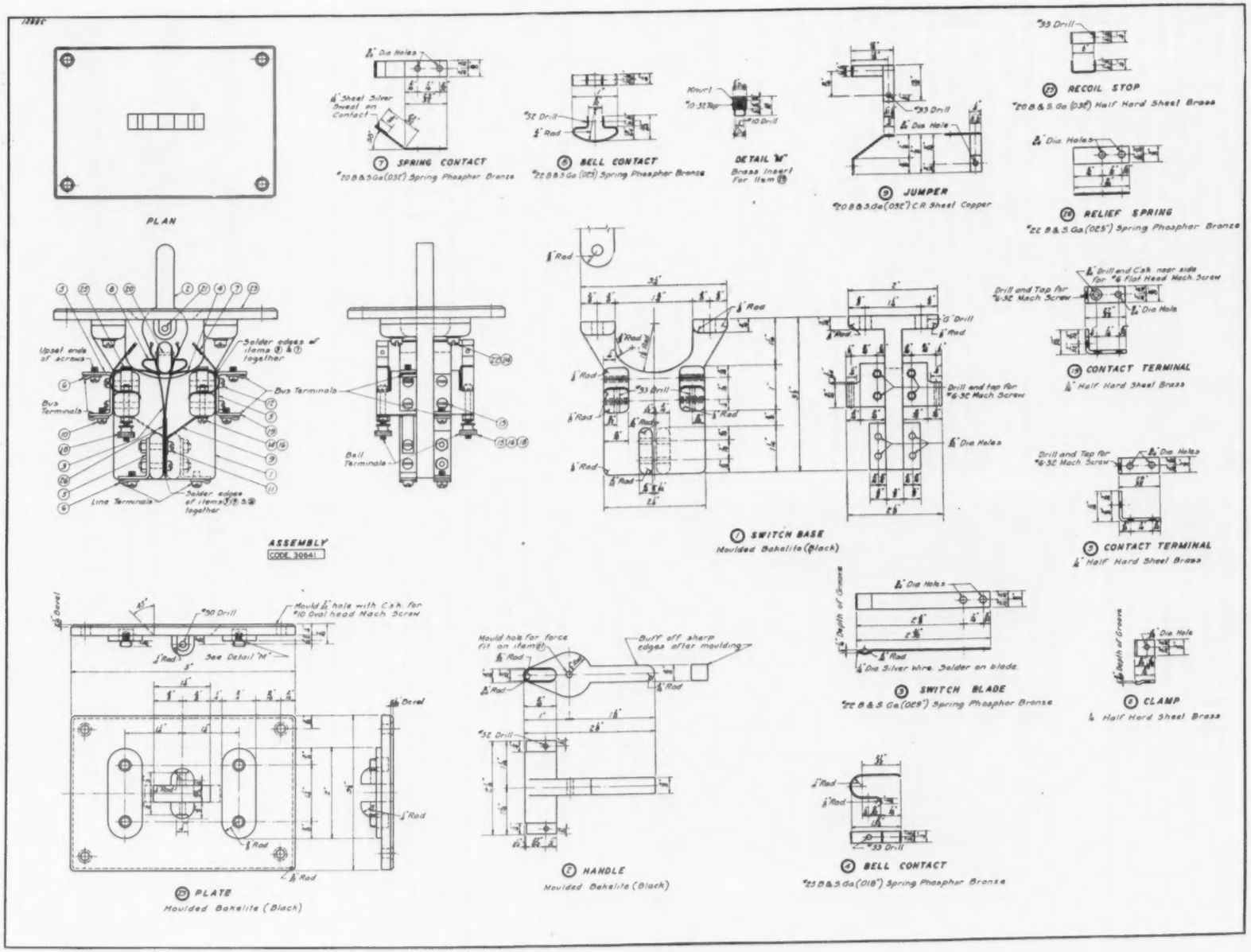


*Fig. 6. Telephone switch, double-pole, triple-throw.*

(involving transmission loss through two transformers in series), drainage coils have been installed in lieu of transformers. For this purpose a drainage coil was developed by the company. The device consists of 12 coils, using the core and case of a 3-kw. distribution transformer, so connected as to give almost perfect capacity and reactive balance between the two sides and ground. The transmission and ringing losses are practically negligible. The coils are tested at 15,000 volts to ground for one minute. The coils are usually connected to the line through a separate standard set of protection, except that 10-amp. fuses are used, which will not blow on minor faults due to surges, leaving the coil connected to the line even when the fuses in the station drop may have blown. Where these coils are installed, it is possible to set the horn gaps and arrester gaps very close; our experience over a considerable period demonstrates that this arrangement affords at least the same measure of protection as where transformers are installed. The drainage coils are considerably more expensive than the transformers. It is not desirable to use them except at stations where the telephone lines are subject to continual use and supervision, because, should only one fuse blow, the line will be seriously unbalanced and noisy. With this in mind, the coils have been connected occasionally on the drop side of the ½-amp. station line fuses, both of which are quite likely to blow under fault conditions.

### Vacuum and Air Gap Arrester

It has been apparent for some time that the combined vacuum and air gap arrester now used is not entirely satisfactory under the severe conditions encountered, both in respect to ruggedness at time of severe fault conditions and to the difficulty of obtaining definite settings at sufficiently low breakdown voltages. We have under test now in the laboratory a new type of carbon gap recently developed and a vacuum tube gap designed primarily for protection of supervisory control circuits. The results of these tests are not yet available. We have also been much interested in the development of the "Serjdetour" by the engineers of the Southern California Edison Company Ltd.

One of the chief difficulties in attaining entirely satisfactory operation of the telephone protective equipment of the power company arises from the fact that its normal care is in charge of the regular station personnel. Without regular direct supervision by men specially trained in the requirements of a telephone plant, it is difficult to impress upon the operating personnel the necessity for proper maintenance of switch contacts, ground resistance, wire clearances, fuses, accurate gap settings, etc. The hazards inherent in "hot" lines are of course materially reduced from time to time as the older circuits are reconstructed, bad joints and wire conditions removed, and proper coordination with the transmission lines effected, thereby reducing both induced voltages and probability of actual contact with the power lines.

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## *Tests on Soldered Sleeve Joints in Telephone Line Construction**

*The tests to be described in this report were made to determine the feasibility of reducing the resistance of sleeve joints in telephone conductors by soldering the line wires to the sleeve, thereby reducing direct-current unbalance in the line to a minimum. As a large percentage of power company communication circuits are exposed to inductive interference to a greater extent than commercial circuits, it has been found necessary to go to extreme limits to reduce direct-current unbalance in order that benefit may be drived from co-ordination.*

SOME time ago the Southern California Edison Company Ltd. realized the necessity of care in the proper sleeving of telephone conductors. Instructions were issued in accordance with American Telephone and Telegraph toll line practice, covering such points as: need for the correct size sleeve, proper cleaning of the line-wires before insertion in the sleeve, use of sleeve containers to keep the sleeve clean until used, etc. Although these instructions were carefully observed, it was found that they were no guarantee of good connection, as will be shown in the case of the circuit to be described.

A telephone line of No. 8 copper wire was constructed between Irvine substation and Laguna Beach, a distance of 10.87 miles. From Irvine substation for a distance of 2.41 miles the line is joint, with one circuit of 66-kv. and one circuit of 11-kv. vertical construction. In this section the 66-kv. and the 11-kv. are not transposed for co-ordination with the telephone circuit. The remaining 8.46 miles is joint, with the 11-kv. horizontally constructed and co-ordinated.

Tests made on completion of the line showed a d.c. unbalance of 4.5 ohms and 5,000 noise units. The over-all measurement for d.c. unbalance proved to be misleading, however, due to compensating resistance as indicated in the table below. It was noticed at the time that the resistance was varying somewhat, as was the noise.

At a later date ten balance tests were made at approximately 1 mile intervals with the following results:

| Test No. | Ohms More In Wire No. | Than in Wire No. | Total Ohms More Than Wire No. 2 at This Point |
|---|---|---|---|
| 1 | 1.8 | 1 2 | — |
| 2 | 0.2 | 1 2 | 2.0 |
| 3 | 1.9 | 1 2 | 3.9 |
| 4 | 2.2 | 1 2 | 6.1 |
| 5 | 1.3 | 2 1 | 4.8 |
| 6 | 1.2 | 1 2 | 6.0 |
| 7 | 0.8 | 1 2 | 6.5 |
| 8 | 0.9 | 2 1 | 5.6 |
| 9 | 0.8 | 2 1 | 4.8 |
| 10 | 0.3 | 2 1 | 4.5 |

The over-all 4.5 ohms additional in wire No. 1 is equivalent to 7,029 ft. more wire in wire No. 1 than in wire No. 2.

As a corrective measure it was decided to solder the present sleeves. A ⅜-in. round file was used to make a notch in the sleeve, ⅜ in. from each end. The notch was made deep enough to penetrate the sleeve and cut into the wire, care being used that the dead end of the wire is notched rather

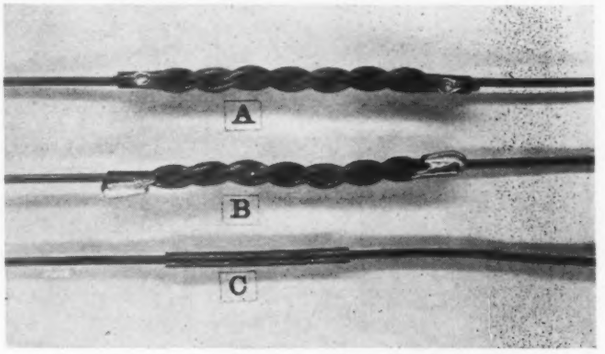


*Fig. 1. (A)—Method used in soldering sleeves in an old line. (B)—Method used in soldering sleeves during construction of a new line. (C)—Splice made with American Telephone and Telegraph Company's sleeve rolling tool for single tube sleeves.*

* Written by R. B. Ashbrook for the subcommittee on power company communication systems, foreign systems co-ordination committee, Engineering Section.

than the line end, so as not to lessen its tensile strength. A soldering iron was used rather than a torch to prevent annealing of the wire, the notch being filled and as much solder sweated in around the wire as possible.

At the time the sleeves were soldered, a resistance measurement was made of each sleeve. Out of 127 joints soldered, only eleven failed to show reduced resistance after soldering.

The work was done by a patrolman, his helper and a test man, a total of 15¼ man-hours being required. All work was accomplished without cutting a wire. In the case of a sleeve joint in a span, the wire was untied and lowered to the ground or to the truck. A special soldering iron, directly connected to a Prestolite tank capable of use in wind, expedited the work considerably.

After correction, the over-all unbalance was 0.1 ohm and the noise was reduced by 4,000 noise units.

Results of the test indicate:

1. That over-all measurements for d.c. balance may be misleading, due to compensating resistances.
2. That sleeve connections, though carefully made, do not guarantee perfect connection.
3. That soldering a sleeve connection in the proper manner reduces the resistances of the joint to a minimum.
4. That soldering sleeve connections is economically practicable.

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## *Sleeve Rolling Tool and Single Tube Sleeves**

*Description of a tool developed by the Bell Telephone laboratories which, where two ends of copper wire are to be joined, rolls the joint with the use of a single copper tube sleeve, cold welded. This does away with the unbalance in the system resulting from the usual practice of splicing the ends, and the use of twisted double copper sleeves.*

THE usual practice of fastening or splicing two ends of copper wire together is by means of twisting the wires and soldering, copper double sleeves twisted, and copper sleeves twisted and soldered. These methods gave strong technical joints, and satisfactory electrical joints when used on ordinary voice frequency circuits. However, due to the very extensive use of carrier current frequencies, slight corrosion in the joint makes an appreciable unbalance in the system. This unbalance is due to the variable resistance of the joint. Corrosion begins by the entrance of moisture and gases into the joint. Present methods and practices do not make the joints moisture proof, or air-tight.

In view of the above difficulties and objections to twisted double copper sleeves, the Bell Telephone Laboratories have developed a machine which, with the use of a single copper tube sleeve, rolls the joint. It may be said that the wire ends and sleeve are cold welded.

The tool is a hand-operated roll, which is driven by a series of gears. A set of rolls, each of which contains two sizes of sleeve grooves, is mounted on each side of the tool. These grooves accommodate four sizes of wire sleeves, 080 and 165 on one side, and 104 and 128 on the other. A portion of the sides of each set of rolls is cut away to permit the insertion and removal of the line wire before and after the joint is made.

When rolling a sleeve over the wire, a pressure between the rolls of approximately a ton is developed from the force of 15 lb. applied at the end of the 6-in. operating lever. The tool, which weighs approximately 4 lb. can be used in rolling the new type sleeves as conveniently as sleeve twisters can be employed in twisting the double tube sleeves.

The sleeve is rolled by operating the handle of the ratchet. The handle of the tool is held perpendicular to the line wire in order to form a straight sleeve. The rolling is started at one end of the sleeve and continued uninterruptedly to the other end of the sleeve. When rolling 080 and 104 sleeves, usually only one revolution of the rolls is required, but for 128 and 165 sleeves it will be necessary to make two or more revolutions of the rolls, in order completely to roll the sleeve and to bring the flat portion of the rolls opposite to permit removal of the tool.

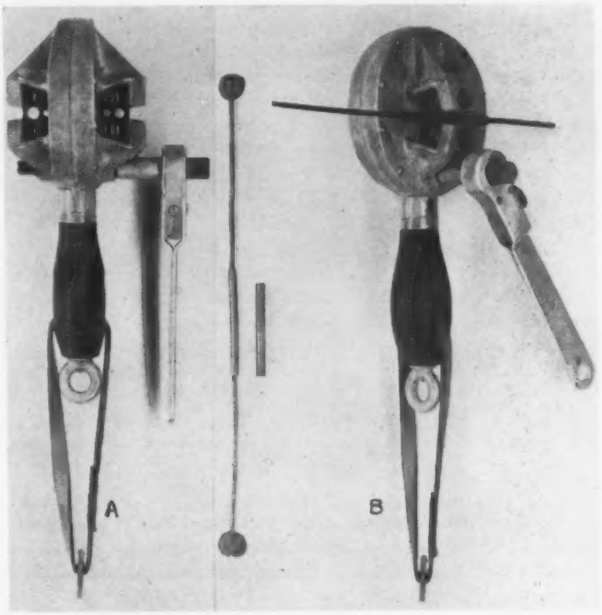


*Fig. 1. (A) Sleeve rolling tool, showing four sets of rollers. (B) The tool and a splice made with single tube sleeve.*

The sleeves are seamless copper tubing. The inner surface of the sleeves is coated with lacquer and powdered abrasive. The lacquer is a resistant to corrosion and also acts as a binder for the abrasive, which, by increasing the holding power, permits the use of a short sleeve.

Test data indicate that, for wire the diameter of which has not been noticeably reduced by corrosion, joints made with these sleeves will develop the full strength of the line wire. The close contact obtained between sleeve and wire makes it unnecessary to employ soldered joints. The new type of joint precludes the entrance of moisture or gases which is an important advantage over the twisted sleeve joint in that it prevents corrosion and the development of high resistance joints. The use of the new type sleeve will effect considerable savings in the copper employed in manufacturing sleeves and will also reduce the amount of line wire used when making joints.

The grooves in the rolls and the four sizes of sleeves are designed for full sized line wire. When the line wire has been reduced, due to corrosion, the strength of the joint is affected. Laboratory tests indicate that the diameter of 080, 104 and 128 wire may be reduced 0.010 in. in diameter before the strength of the joint is below that of the wire. In the case of 165 wire, the reduction of diameter is more critical. Wires 0.157 in. in diameter, joined with a 165 rolled sleeve, show that the strength of the joint is about 20 per cent less than the strength of the wire. Single tube sleeves have not been provided to take care of wire that is below the limits mentioned above. Under such conditions and also

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* Written by M. A. Sawyer for power communication systems subcommittee, foreign systems co-ordination committee, Engineering Section.

in cases where two wires of different sizes are to be spliced and at deadend points, it will be necessary to make twisted sleeve joints.

## *Remote Alarms Over Telephone Circuits**

*An economical system of remote alarms developed by the Southern California Edison Company Ltd. for its unattended substations is here described.*

A definite trend in the power industry is the increasing use of automatic devices to replace manual operation. Complete automatic operation is being practiced to some extent in hydro-electric generating stations and is widely practiced in substations of various types. The trend is definitely toward wider use of automatic devices and new types and applications of such devices are being constantly developed. For the purposes of this paper automatic substation operating devices may be roughly divided into two groups: supervisory control, and full-automatic with remote alarm indication. In the first, the control of the unattended substation is under the direct supervision and control of an operator at a remote attended substation, through the medium of an intricate relay system, operating over control lines extending between the attended and unattended stations. Restoration of service following circuit failures at the unattended station is entirely dependent upon the proper functioning of the remote control device and upon the reliability of the control lines. In full automatic substations, circuit breaker reclosing devices and relay controlled emergency feed circuits automatically restore service, independent of control from any remote point. A remote alarm is given in an attended station over some form of signal circuit, so that maintenance crews may at once determine the cause of the circuit failure and remove any possible hazard that may be present.

In the supervisory controlled systems, the necessity of absolute reliability in the control circuits makes for a high cost in their construction and maintenance, a cost that is almost prohibitive over long distances. In the case of the full-automatic system, the reliability of the signal circuits over which the remote alarm is given has no bearing upon the restoration of service and its construction may be comparable to usual telephone line construction practice, with modifications in terminal equipment.

The Southern California Edison Company Ltd., having adopted the system of full-automatic control for its unattended substations, an economical system of remote alarms became desirable. The system as developed by the company is here described.

### The Simplex

An expensive network of privately owned telephone lines supplies service to the majority of unattended substations requiring remote alarm service. The economy involved in the use of these lines for the carrying of the remote alarm signals warranted the expense of alterations in the usual method of telephone protection made necssary for the two-fold service.

By the use of a "simplex" circuit, the alarm signals are superimposed upon the telephone circuit with no interference to the normal functioning of the latter. As the lines over which the simplex is to operate are, in a great majority of cases, built joint with, or closely paralleling, power circuits of from 10 kv. to 66 kv., they are subject to severe

* Written by B. W. Fordham for the power communication systems subcommittee, foreign systems co-ordination committee, Engineering Section.

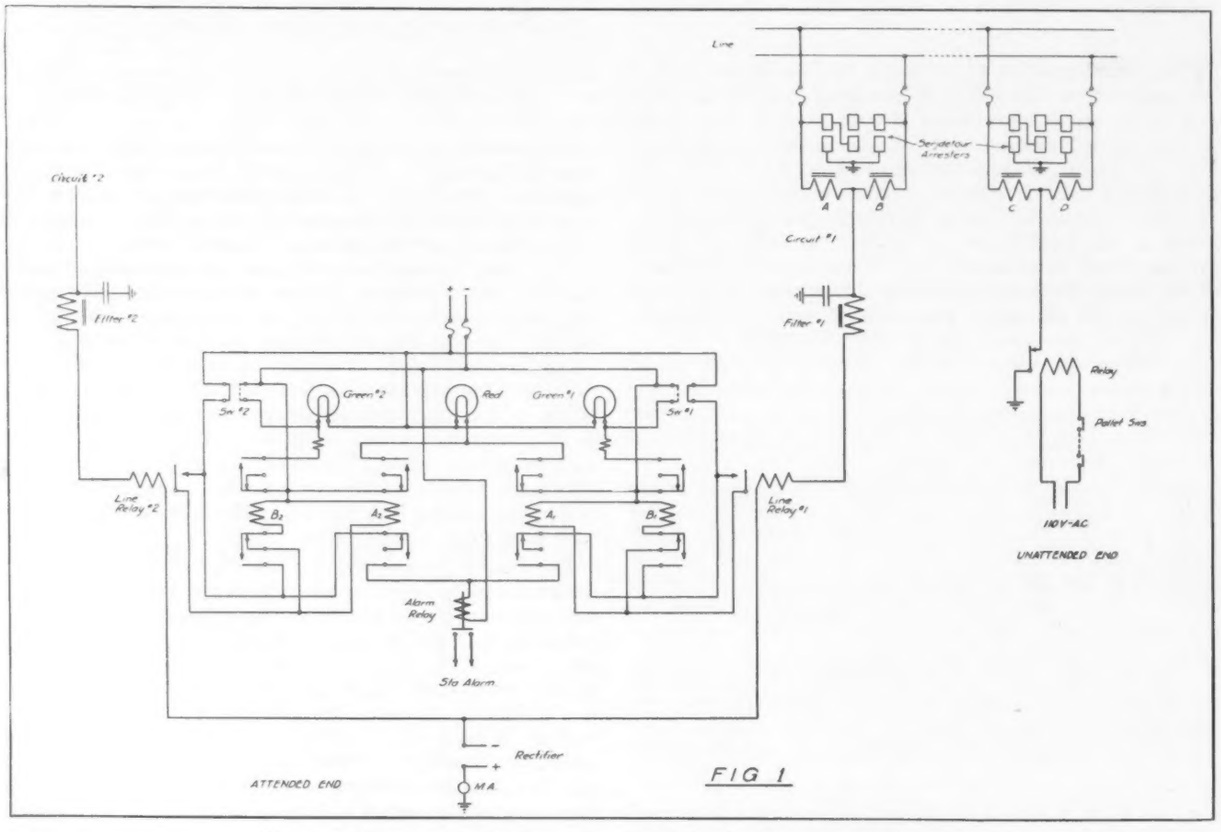



*Fig. 1. Schematic wiring diagram of unattended substation alarm equipment.*

inductive interferences under fault conditions and it is evident that adequate terminal protective apparatus is required for reliable operation. This protection is provided by use of the Serjdetour protector developed by the company and used throughout its communication system. (This is described in another report.) Since the Serjdetour definitely limits the voltage to ground to 1,700 volts, special equipment capable of handling this potential is needed in making up the simplex and the line circuits of an alarm system.

The line bridging coils A, B, C, and D of Fig. 1, are used for making up the simplex and have 63 henrys inductance, a resistance of 220 ohms, and are insulated to handle 2,000 volts. Fig. 2 is a photograph of the weatherproof line bridging coil unit. Use of these coils for making up the simplex, rather than the split windage of an insulating transformer, the secondary of which would be available for telephone use, is for the following reason: In a transformer the coils are on the same core, with windings in the same direction. Induced currents to ground in the telephone line (or currents from a primary contact, where the contact is with both wires of the telephone line) would pass through the coils in opposite directions to the mid-point, neutralizing the impedance and allowing large values of current to flow. Although an impedance could be inserted in the simplex leg, it has been found that available transformers, capable of handling 1,700 volts, present such losses to the telephone circuit when their windings are connected in series, that they are undesirable for telephone use. The inductance coils of Fig. 1 are therefore found to be the more suitable. The bridging impedance is so high as to present no appreciable loss to the telephone circuit at ringing or talking frequencies.

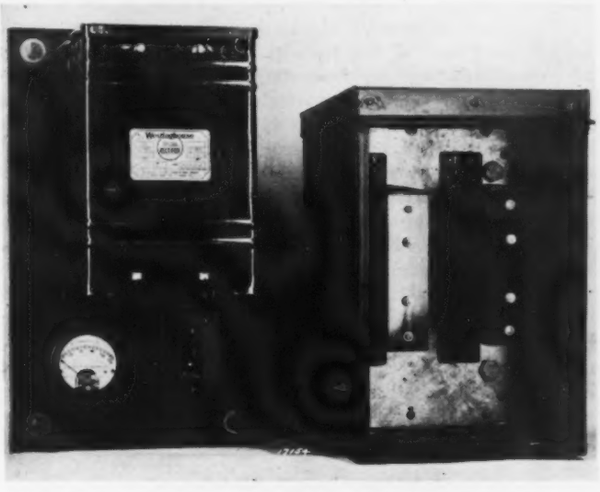


*Fig. 2. Left, the power supply unit. Right, the inductance coil unit, containing the two bridge inductance coils.*

### The Receiver

A filter connected in the relay coil circuit, Fig. 1, is effective in preventing induced a.c. voltage from the telephone line to ground from chattering the line relay. The voltage gradient of the circuit is such that, under the maximum hazard (1,700 volts, as controlled by the arrester), the voltage across the filter condenser is approximately 350 volts. This condenser consists of a pair of 1 mfd., 1,000-volt telephone condensers in parallel. The small filter choke has 20 henrys inductance and 210 ohms resistance.

The line relay is an ordinary 150-ohm main-line telegraph relay, requiring a current of from 0.030 amp. to 0.085 amp.

The source of direct current for the simplex circuit is a dry-element rectifier (Fig. 2), designed for charging batteries and which will deliver sufficient current to supply several simplex systems. The rectifier has proven satisfactory over more than a year of service; doing away with maintenance and inspection of batteries, it being impossible to use the station battery as a power supply for the simplex, because of the inadvisability of grounding the station battery. A milliameter is associated with the rectifier for reading the simplex current.

The filter, line relay and the local signal circuit are built into an "alarm receiver" unit, which is shown in Fig. 3. The receiver may be equipped for one or two circuits. The source of direct current for the local circuit is supplied by the station battery, usually 32 volts. Functioning of the receiver is as follows:

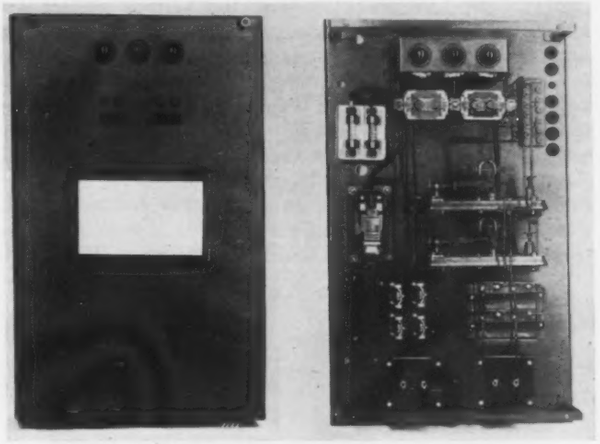


*Fig. 3. The alarm receiver. At right, with cover removed.*

Simple circuit No. 1, Fig. 1, is opened at the unattended station by opening of a pallet switch, or by the station going black, either of which releases the pallet circuit relay. The line relay in the receiver at the attended station is de-energized, the back contact of which operates relays $A_1$ and $B_1$. One set of "make" contacts of relay $A_1$ lights the red lamp; the other set of "make" contacts of this relay operates the alarm relay, the contacts of the latter operating alarm bells as required in the particular station. Relay $B_1$ locks itself by the lower set of "make" contacts, while the upper set of "make" contacts lights the green light associated with circuit No. 1. If the line relay should be again energized, by the remote pallet circuit relay returning to normal, relay $A_1$ will open, releasing the alarm relay and extinguishing the red light; the green light, however, will remain lighted with the receiver switch in the off-normal position. Returning the receiver switch to the normal position extinguishes the green light and the receiver is normal.

### Remote Indication of Recloser Action

In event of the action of a circuit breaker reclosing mechanism at the unattended station the receiver would function as follows:

A circuit breaker opens; its associated pallet circuit relay opens, bringing in an alarm at the attended station, the red light and the green light associated with that circuit lighting. After a certain short interval, the reclosing mechanism operates and the circuit breaker remains closed. The alarm bells in the attended station stop, the red light extinguishes, but the green light associated with that circuit remains to indicate which remote station had experienced the trouble. This is important, as it is sometimes impossible in small one-man stations for the operator to be close enough to the alarm equipment to observe which of a number of alarm circuits the trouble is on, before the circuit is restored by the recloser. Were it not for this requirement, the local circuit would need no auxiliary relays.

In event of a circuit reclosing three times and locking-out, the operator at the attended station may stop his alarm bells by throwing the receiver switch to the off-normal position, thus releasing relays $A_1$ and $B_1$, Fig. 1, the green light on that circuit remaining lighted. He may at any time test the circuit by throwing the receiver switch to normal, the alarm and red light continuing to come in until the line relay is again energized by the unattended station returning to normal.

### Pallet Switch Circuits

The pallet circuit in the unattended station has been given considerable attention and an economy found in use of an auxiliary relay, the current for which is supplied from the station light and power through the various switches in series, the relay being normally energized, its "make" contacts closing the simplex to ground. Should the station feed fail, the relay is released, giving an alarm, thus making unnecessary pallet switches on the circuit breakers in the lines feeding the station. Where it is necessary to carry remote alarms from two or more unattended stations over one simplex circuit to a single receiver, a code-device (Fig. 4) is used in the pallet switch circuits at the unattended stations, which, by interrupting the alarm by a code, indicates to the operator at the attended station where the alarm

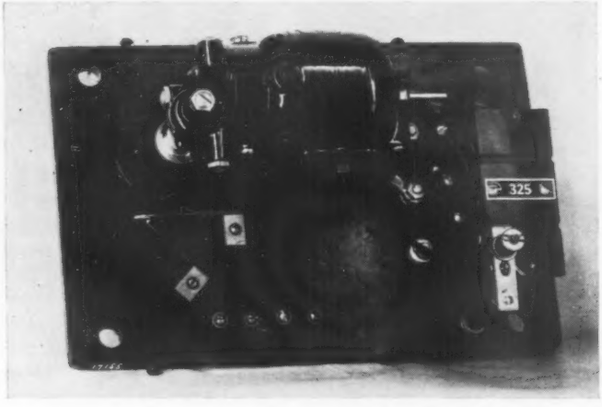


*Fig. 4. The code device.*

originates. This code device consists of a small a.c. motor, connected by a 1,200 to 1 reduction gear to a notched wheel, which in turning opens and closes a pair of contacts. The circuit used is shown in Fig. 5. Relay A serves to close the simplex, should the contacts of the code wheel stop in the open position. Relay B gives a no-voltage indication as previously described. In event of no voltage, the alarm is

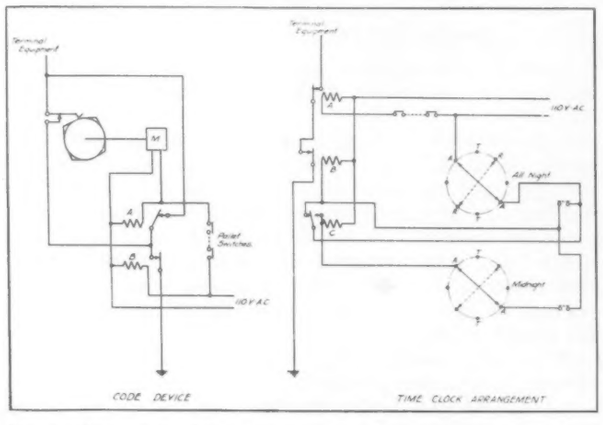



*Fig. 5. Schematic wiring diagram of unattended substation alarm for coding and time clock arrangement.*

not coded. It was deemed unnecessary to provide auxiliary power supply for the code device, as the load dispatcher should be able to determine quickly the source of the alarm, should a total station load be dropped.

Street light circuit breaker operations are checked by means of the circuit of Fig. 5. There is a circuit breaker for the all-night circuit and another for the circuit that is dropped at midnight and a time clock for each breaker. The reclosing mechanisms for both breakers are operated by the all-night clock, which closes at 6 p.m. (or therabouts). The midnight clock trips its breaker at midnight and the all-night clock trips its breaker at daybreak. The midnight clock resets sometime during the day, the time being unimportant, as it has no reclosing connection. When the all-night clock closes at 6 p.m., there is a short interval between the time when the clock operates and the circuit breakers close, when an alarm is given. This alarm, being of a certain known time duration and coming at an expected time, indicates to the attended station that the circuit is closed. If the midnight clock had failed to reset during the day, its contacts would be in a trip position when the all-night clock closed and the midnight circuit would immediately kick out, giving an alarm. Opening of the circuit breakers, due to causes other than operation of the time clocks, gives an alarm as with the usual circuit breaker.

### Simplex Circuit Supervision

The use of a closed simplex is to be desired. Open circuit systems are subject to false operations, due to partial grounding of the telephone line. On telephone lines that are infrequently used, the open simplex alarm system may be inoperative for a considerable time, due to open fuses in the telephone line.

When a closed simplex circuit is used, a continuous check on the condition of the simplex may be had by means of current readings on the meter associated with the rectifier. This meter normally indicates the sum of the currents flowing through all the simplex systems at that station. This "station normal current" is recorded, as well as the normal currents in each individual circuit. The operator takes hourly readings, and should he observe the rectifier current to be off-normal, he may determine which circuit the trouble is on by testing each circuit individually. A ground on a telephone line carrying a simplex will, by lowering the loop resistance, cause a rise in current. A telephone fuse, open in one side of the line, causes a drop in current. Although the operating limits of the line relay are wide, a close check on the condition of the simplex is kept and serious troubles are thus anticipated and cleared before they develop to a point where the alarm is inoperative. It is needless to say that the telephone circuit benefits from this close supervision.

### Simplex Circuit Variations

The simplex circuit is so flexible as to be readily adaptable to any condition the telephone network may present. As has been said, the bridging inductances offer so high an impedance to telephone frequencies that they may be inserted wherever needed, with no appreciable loss to the normal functioning of the telephone circuit. The insulating transformers used, when connected in parallel, include a transmission loss of only 0.5 decibel.

Four typical simplex combinations in operation on this company's system are shown in Fig. 6. Where it is desired to carry two alarms over one line, one of the unattended stations being on a tap line, as in (1), Fig. 6, a closed circuit simplex cannot be used, as the ground connection in one unattended station is in parallel to, and bypasses the other. An open circuit simplex is therefore used with a code device to indicate where the alarm originates. Should the intermediate station be located on the telephone line, where it is possible to loop the line through, the circuit of (2), Fig. 6, is used, and the more desirable closed circuit is

made possible. The isolating transformer completes the telephone circuit through the intermediate station, only the simplex circuit being looped through the code device. If the attended station happens to be the intermediate station, the two simplex circuits are isolated by means of a transformer as in (3), Fig. 6. Isolating transformers, their windings protected by a single-unit between-wire Serjdetour arrester, many be included in the line at any location to separate two alarm systems, as shown in (4), Fig. 6.

It might be interesting to note that one telephone line on this company's system, approximately forty miles in length, carries alarms from five unattended stations, over four separate simplex circuits. There are eight sets of inductance units and five insulating transformers in the line. Ten miles of the line serves as one side of a phantom circuit. Approximately thirty miles of the line is built joint with 16 kv. and 66 kv. This is an important line handling a large amount of telephone traffic, the normal functioning of which is in no way injured by the apparent heavy loading.

# *Radio Co-ordination**

*The report of the committee covers the subjects of co-operative investigation, a standard form of reporting, classifying and summarizing radio interference complaints, radio interference test sets, radio interference from household devices, methods of filtering interference from distribution lines and services and the problem of radio installations as affecting the utility, and the effect of voltage on the life of a.c. radio tubes.*

FOLLOWING is an outline of the activities of the subcommittee on radio co-ordination for the year 1930-1931. This report includes the main topics studied and discussed by the subcommittee during the past year.

## Co-operative Investigations

Interference investigations by the Pacific Radio Trade Association and the Southern California Music and Radio Trade Association in co-operation with the utilities have been carried on throughout the past year. The Pacific Radio Trade Association's activities cover the bay area, including San Francisco, Oakland, Berkeley, Richmond, San Leandro, Hayward and Alameda. The Southern California Association includes in its territory Los Angeles, Long Beach and other cities and towns near Los Angeles. This plan of conducting radio interference investigations is apparently work-

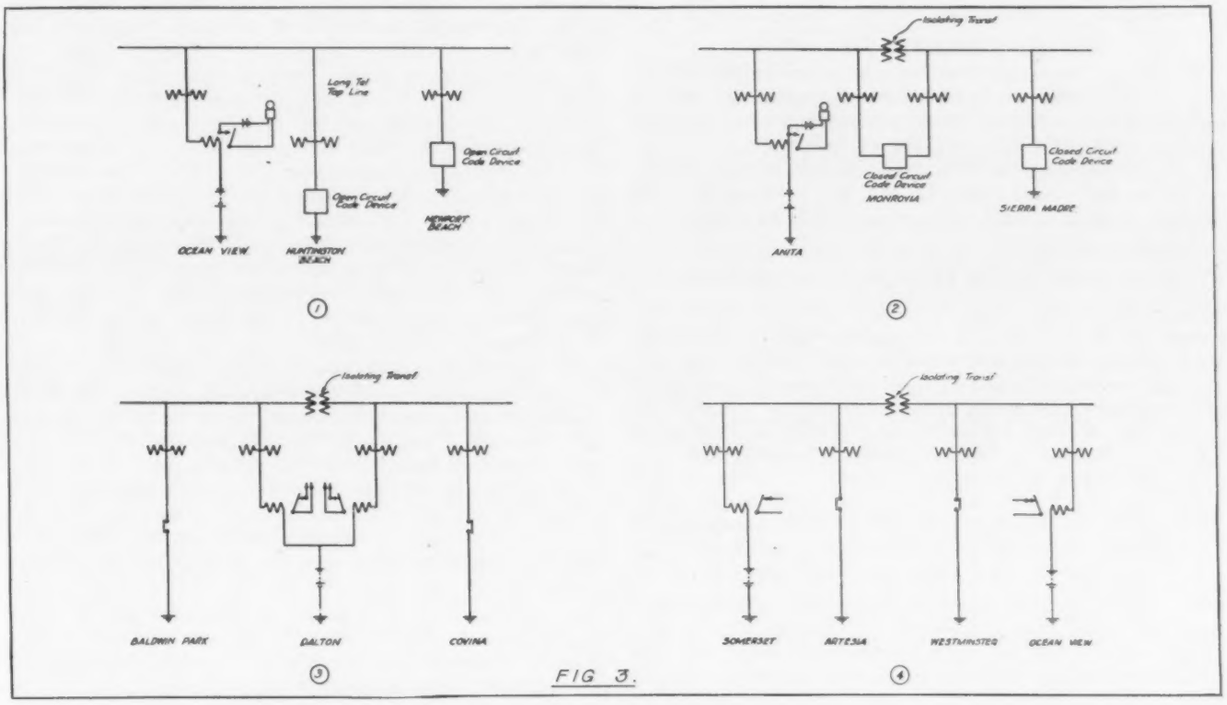



FIG 3.

*Fig. 6. Single line wiring diagram showing typical installations of unattended substation alarm equipment.*

## The Simplex Bypass

Where it is necessary to make connection between a Class "C" exposed telephone line and a Class "C" unexposed telephone line, the former being a line built in proximity to power circuits in excess of 5 kv., it is necessary to connect the telephone lines through an insulating transformer. A filter is used to bypass this transformer for accommodation of a simplex circuit. The filter has a cut-off frequency of approximately 40 cycles and is effective in preventing the passage of a.c. potentials to the unexposed line. Small 1-amp. fuses are included in the filter circuit as an added precaution, although in a test under actual working conditions these fuses failed to blow when the exposed line was contacted with 66 kv.

* Report of subcommittee on radio co-ordination, foreign systems co-ordination committee, Engineering Section. C. C. Campbell, chairman. I. L. Bateman, F. D. Beardsley, E. D. Brown, D. I. Cone, A. W. Copley, G. H. Curtiss, F. B. Doolittle, A. S. Glasgow, W. F. Grimes, O. A. Gustafson, O. W. Holden, C. B. Judson, H. N. Kalb, C. M. Lindsley, N. A. Sawyer, A. Scott, J. F. Spease, G. R. Walters.

ing out satisfactorily. One of the desirable features of this plan is the investigation and elimination of all sources of interference regardless of its origin.

### Standard Form for Reporting, Classifying and Summarizing Radio Interference Complaints

The following suggested standard form for reporting radio interference complaints was made up and sent to all member companies. From the replies and suggestions received the following form has been made up. It is planned to have this report form for use by future subcommittees for collecting and totalizing reports from various member companies.

| Cause of Interference | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 |
|---|---|---|---|---|---|---|
| a. Utility Equipment | | | | | | |
| b. Other Utilities' Equipment | | | | | | |
| c. Industrial Appliances | | | | | | |
| d. Household Appliances | | | | | | |
| e. Faulty Radio Sets | | | | | | |
| f. Faulty Radio Installations | | | | | | |
| g. Natural Static | | | | | | |
| h. Other Miscellaneous Sources | | | | | | |
| i. Clear When Investigated | | | | | | |
| j. Total Number Investigated | | | | | | |

### Radio Interference Test Sets

There is an increasing need for a better radio interference test set. Since the change from battery operated sets to sets operated on the a.c. lines, interference complaints are often received from owners of sensitive a.c. sets which cannot be traced with some of the older type test sets now in general use. Several sets have been tried out, but there are still differences of opinion as to just what should be expected in such a set.

### Radio Interference From Household Devices

Radio interference from household appliances has been brought to the attention of the manufacturers of electrical appliances by the national committee. It is hoped that this will tend to decrease, and in time eliminate, all new appliances causing interference. This can be done at a small cost to the manufacturer and as the ones now in use are worn out or are filtered for radio interference, trouble from this source will gradually decrease.

### Methods of Filtering Interference From Distribution Lines and Services and the Problem of Radio Installations as Affecting the Utility[1]

The filtering of distribution lines and services has become important, since the paralleling of these lines with transmission circuits has become more frequent. When such an exposure exists and is of some considerable length, any interference originating on the transmission line may be picked up by the distribution circuits and carried for considerable distances. When, as is often the case, these lower voltage lines penetrate into urban areas, interference is often carried into the home and to the radio set by means of the house wiring. Many of the standard a.c. sets today do not provide means to filter out interference picked up in this manner and such interference is often as objectionable as that picked up by the antenna system. As a matter of fact whenever interference enters the set by way of the a.c. lines, it is almost always being picked up by the antenna system as well.

Other interference than transmission line noises is often picked up and carried for some distance by the distribution circuits. Household appliances, industrial motor starters, electro-medical equipment and other apparatus sometimes generate interference which travels out over the service wires and is spread over a considerable area. While the utility can not be responsible for the correction of this interference, it is generally a case of our being assumed guilty until we prove ourselves innocent, and this means locating the trouble and recommending either methods of eliminating it or preventing its distribution.

There are three generally recognized ways of dealing with this trouble. The first, of course, is to eliminate the interference at its source. The second is to prevent it radiating by means of the distribution lines. The third is to keep it out of the radio set, even if it is present in the service lines.

The first method is, of course, to be preferred, but unfortunately is not always practicable or economical. If the trouble is on the transmission system, it may call for the expenditure of large sums of money in order to eliminate it. In the case of household appliances, any repairs made to the apparatus usually give only temporary relief. These repairs cannot well be made by the power company, as it is not their equipment and to do so would establish a bad precedent.

The second method is the prevention of troublesome noise spreading out through the distribution system. In the case of appliances, a small filter is often all that is necessary. We have found but few cases where the owner of such appliances has refused to purchase an inexpensive filter, once he is convinced that the trouble lies in his equipment.

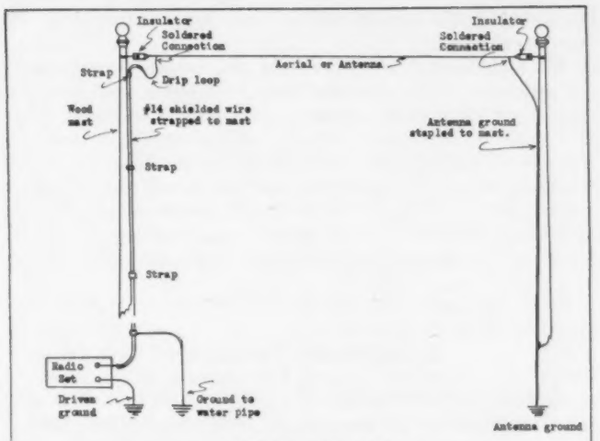
Some experimental work has been done with choke coils in the distribution conductors at the point or close to the point where such circuit leaves the transmission line. We have had very scant success working along these lines. The idea worked out very well in the laboratory, where an artificial source of interference was used, but practically it did not work out on the job, where a multitude of different frequencies and harmonics had to be suppressed. The reactors, in order to carry the necessary current, were quite bulky and it was felt by our operating department that they constituted a distinct operating hazard in the event of a lightning stroke or a short circuit, where the reactor would be subject to a tremendous mechanical strain. However, our experiments were not carried to any great length and cannot be regarded as conclusive.

We have had considerable success in working out this problem at the service end of the system. It is usually inadvisable to try to filter the line at the meter, on account of the comparatively heavy load at this point and the cost of a filter that would handle it. We have found that a good filter in the a.c. line at the radio set, in conjunction with a shielded antenna lead-in, gives a very satisfactory solution in many cases. A great deal of educational work has been done along this line among the dealers on our system, with gratifying results.

There appears to be a diversity of opinion among radio engineers as to the worth of a shielded antenna installation. There is no doubt that the matter of poor installation of the radio set, antenna and ground has been the cause of a good many complaints of interference reaching the utilities. We have laid stress upon this in our contact with the dealers and our customers. At several points on our system, we are not investigating radio complaints unless the set is equipped with a satisfactory antenna and ground system. By this is meant the system as recommended by the manufacturer.

An explanation of the two types of special antenna systems which are generally very effective may not be out of place here. The first is known as the shielded lead-in type. This has, as a fundamental requirement, a good, high flat top, generally 100 to 150 ft. long, varying greatly with certain factors, such as signal strength, ground noise level, length of lead-in, type of set, etc. The lead-in from this flat top consists of a shielded wire of No. 14 to No. 18 size, insulated with rubber similar to a lamp cord and having a conducting braid woven on the outside, but, of course, insulated from the core. This lead-in is brought down to the set in the conventional way and the shield is grounded, sometimes to the ground terminal of the set and sometimes to an

[1] Prepared by C. M. Lindsley for the radio co-ordination committee.

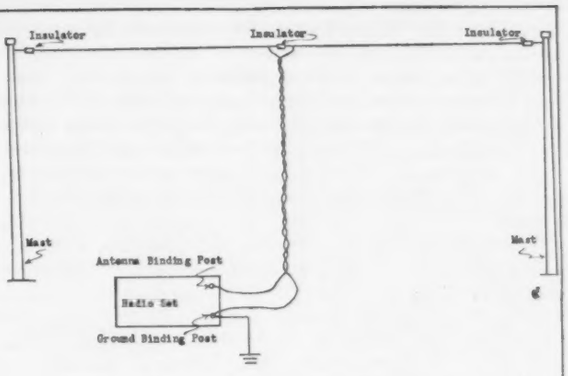



SPECIFICATIONS

1. Flat top of antenna should be of #12 or #14 bare or enameled copper wire 35 or 40 ft. above ground and should be well in the clear of trees and building.s
2. Lead-in should be of #14 lead covered wire or other shielded conductor. Shield should be removed to a point on down bend of drip loop as indicated on drawing and should be taped.
3. The shield should be grounded to a water pipe.
4. The set ground must be of low resistance. A copper ground cone or an old automobile radiator core makes a good ground if buried 4 ft. deep and wet down with water and 5 or 10 lbs. of rock salt. Solder the ground wire to the ground and make the ground lead as short as possible.
5. Ground the free end of the antenna either direct as shown or thru a 10,000 ohm resistance. This ground may be a driven rod.
6. The ratio of length of lead-in to length of flat top should be about 1 to 4. A 35 foot lead-in with 125 to 150 ft. of flat top makes a good average combination.
7. All electrical connections should be well soldered.

DETAILS AND SPECIFICATIONS COVERING
DESIRABLE TYPE OF ANTENNA AND GROUND INSTALLATION
FOR RADIO RECEIVING SET

*Fig. 1. Details and specifications covering a desirable type of antenna and ground installation for a radio receiving set.*




SPECIFICATIONS

1. The total length of the flat top portion of the antenna should be about 600 ft. This should be broken by an insulator in the center as shown and #17 telephone duplex drop wire tapped on and brought in to the set.
2. The flat top portion of the antenna may be located up to 2000 ft. from the radio set. In general, the further away the better.
3. Better results can sometimes be secured by grounding the ground terminal of the set in addition to attaching one of the duplex wires to this terminal.
4. To make this arrangement effective the set should be perfectly shielded. Most of the later A.C. sets are so constructed.
5. A good filter should be used in the 110 volt supply circuit, as close to the set as possible.

SPECIFICATIONS FOR RADIO RECEIVING ANTENNA

OF A TYPE ESPECIALLY SUITABLE FOR SERVICE AT LOCATIONS
WHERE INTERFERENCE FROM LOCAL POWER EQUIPMENT IS SEVERE

*Fig. 2. Specifications for radio receiving antenna of a type especially suitable for service at locations where interference from local power equipment is severe.*

independent ground. The ground is important and we always determine by definite measurement just how good it is. We have found that a ground which measures 15 ohms or less by the conventional three-point d.c. method is satisfactory. We recommend a salt treated ground and a copper clad ground rod. It is sometimes of advantage to ground the free end of the flat top portion of the antenna, either directly or through a variable resistor of 10,000 ohms. This act tends to throw the average antenna into resonance with some frequency inside the broadcast band and so produces a higher signal to noise ratio. This type of installation has been found quite satisfactory in the majority of cases.

The second type, I believe, is superior in some ways to the first, but unfortunately takes up more space than is generally available. This is what is known as the doublet antenna. We use No. 19 duplex telephone drop wire for the lead-in. A long half-wave antenna is erected at a distance of several hundred to a thousand feet from the radio set, in order to get it out of the interference field. The antenna proper is generally made approximately 600 ft. long, broken in the center by a strain insulator. One conductor of the duplex lead-in is attached to the antenna on either side of the strain insulator. The duplex acts as a radio frequency feed line, with practically no pick up along its entire length. In addition it is sometimes advisable to ground the ground terminal of the radio. If a well shielded set is used, this type will generally relieve the most obstinate cases of interference.

It seems to me that the utilities in general have not been giving the matter of installation the attention it deserves. Our problem is not so much actually clearing interference, as it is satisfying our customers. If the results can be obtained by some economical method other than eliminating the trouble at its source, it would seem in many instances the logical thing to do. The customer wants satisfactory reception and if in some cases there exists a solution more economical than actual reconstruction work, it at least deserves careful consideration.

### Effect of Voltage on Life of A.C. Radio Tubes[2]

The life of a tube filament depends upon a rather surprising number of factors, in addition to the filament voltage; among the most important of these factors being voltage difference between filament and plate, the amount and kind of residual gas in the bulb, and the normal operating temperature of the filament.

As an approximate method we may use the formula for life of incandescent lamp filaments, which is:

$$\frac{l}{L} = \left(\frac{V}{v}\right)^x$$

l - life of filament at abnormal voltage.
L - life of filament at normal voltage.
V - rated voltage.
v - abnormal voltage.
x - exponent which has a value between 9 and 13 for various types of tungsten filament lamps.

This formula is applicable to ordinary vacuum tube elements if we use for x, a value between 4 and 9.

An exact value for the exponent, of course, cannot be given, as tubes of various kinds and manufacture vary as to operating temperature of the filament at rated voltage, diameter of the filament wire and numerous other factors. As a general rule, standard vacuum tubes are designed to give satisfactory performance with a filament (or heater) voltage variation of plus or minus 5 per cent from the normal rated value.

If the line voltage increases more than 5 per cent, the life of the tubes will be materially endangered, as the formula

2 Prepared by O. W. Holden for the radio co-ordination committee.

shows that the filament life varies inversely as some power of the ratio of increased voltage to the normal voltage.

The life of tubes is also affected in a secondary manner, due to the fact that the line voltage variation of 10 per cent changes the average output of the rectifier tubes about 15 per cent. This means that, if the line voltage increases unduly, all tubes in the receiver proper suffer changes in potential to all their electrodes in proportion, the filament excepted.

Besides affecting the life of the filament, line voltage variations result in changes of one or more of the following characteristics:

| | |
|---|---|
| Mutual Conductance | Plate Resistance |
| Emission | Plate Current |

If the mutual conductance or the plate current are reduced, the sensitivity and the maximum undistorted output of the receiver will decrease. Increases in mutual conductance may result in oscillation of the receiver. Either condition will result in poorer quality of reproduction from the receiver.

Changes in plate resistance of the tubes upset the impedance matching of the amplifiers and result in changes of frequency response characteristics.

One of the manufacturers furnishes the following data as an example of how line voltage variations affect performance:

A 5 per cent change in line voltage gives about 10 per cent change in sensitivity. A 10 per cent change in line voltage causes about 20 per cent change in sensitivity. If the line voltage decreases by more than 10 per cent, the sensitivity begins to drop off much more rapidly than for variations of smaller magnitude.

The particular receiver from which this data was obtained was almost entirely free from regeneration. The average radio receiver obtains some of its sensitivity through regeneration and in this case a line voltage variation of plus or minus 10 per cent would cause a much greater change in sensitivity than indicated.

Although maximum sensitivity of reception will obtain under conditions of least voltage variation, it appears that no damage will result to the tubes under voltage variation conditions within 5 per cent plus or minus, and it is believed that most utilities, at least in the urban districts, maintain their consumer's voltage within these limits. In rural territories, where the voltage level may differ from ordinary standards, although the daily variations from this level may not exceed 5 per cent plus or minus, the situation can be handled by means of taps on the power transformers in the sets, to adjust for the particular condition existing. If, however, the voltage fluctuates more than 5 per cent, the consumer may have some real cause for complaint.

There are sets on the market which are provided with devices for automatically regulating the voltage to the set and such type of receiver would be most suitable for territories where the density of load does not warrant close voltage regulation.

From information supplied by the better manufacturers of receivers, it is apparent that no trouble will be experienced within ordinary commercial voltage conditions. There is, however, no reason why the utility should assume any burden of adapting its practices to accommodate the manufacturer of inferior equipment and we should not hesitate in telling the complainant the truth. We are already sufficiently burdened with the responsibility of maintaining our system clear of legitimate causes of radio interference.

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## *Common Neutral**

*A report summarizing the developments in this field to date, together with a set of practices agreed upon to govern relations between power and communication companies when the common neutral system is used, was presented to the California Railroad Commission in June, 1930. The commission now awaits additional data from Chico before rendering its decision.*

THIS subcommittee transmitted its report to the California Railroad Commission on June 19, 1930. The report summarized the developments up to that date, the formation of the subcommittee, the tests conducted with the assistance of eastern personnel and equipment, and the results on ten 4,000-volt distribution areas which had been cut over to common neutral under special permission of and construction rules issued by the Commission for a trial period which was to end July 1, 1930. A set of practices agreed upon to govern the relations between power and communication companies, when the common neutral system is used, accompanied the report.

The Railroad Commission has awaited the completion of the cutover and report of tests on an additional area (Chico), in order that data on all areas allowed for in the trial period could be considered before its decision is rendered. During the intervening time, certain minor changes have been made in the practices, and discussions have been held with engineers of the commission regarding construction rules.

When the Chico data is in, a final report will be presented to the Railroad Commission and a formal hearing will be held, at which time the commission's decision will be rendered and construction rules issued.

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* Report of subcommittee on common neutral, foreign systems coordination committee, Engineering Section. L. J. Corbett, chairman. J. O. Binney, vice-chairman. K. B. Ayres, R. G. Boyles, D. I. Cone, R. R. Cowles, T. J. Fleming, E. R. Northmore, M. A. Sawyer.

# HYDRAULIC POWER COMMITTEE REPORTS[1]

## *Special Alloys For Hydraulic Equipment**

*The application of special and hard-faced alloys to hydraulic equipment is still in the experimental stage, but sufficient data have been assembled by the Pacific Gas and Electric Company, the San Joaquin Light & Power Corporation and the Southern California Edison Company Ltd. to form a basis for this report.*

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* Report of subcommittee on special alloys for hydraulic equipment, hydraulic power committee, Engineering Section. J. M. Gaylord, chairman.

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[1] C. M. Mardel, Pacific Gas and Electric Company, chairman. G. B. Carlson, Southern California Edison Company Ltd., vice-chairman.
California Corrugated Culvert Company: A. C. Norton.
General Electric Company: W. C. North.
Los Angeles Bureau of Power & Light: R. R. Robertson.
Pacific Gas and Electric Company: R. E. Ballew, G. H. Bragg, E. A. Crellin, D. P. Dinapoli, W. Dreyer, J. R. Johnson, R. F. Krafft, F. I. Lawson, E. N. Murphy, B. N. Merritt, C. P. Vetter.
Pelton Water Wheel Company: E. M. Breed, C. V. Foulds, R. S. Quick.
San Francisco Engineering Department: L. P. McAffee.
San Joaquin Light & Power Corporation: F. R. Harp, J. W. Jourdan, Oren Reed, C. E. Schnell.
Southern California Edison Company Ltd.: S. F. Coghlan, J. F. Davenport, J. M. Gaylord, F. Gfeller, P. H. Gilbert, Lloyd Hunt, R. M. Peabody.
The Southern Sierras Power Company: C. L. Davis, Geo. M. Wills.
Taper Tube Pole Company: Clinton DeWitt.
Westinghouse Electric & Manufacturing Company: H. S. Warren.

FROM the data collected it is apparent that the application of hard facing to impulse turbine parts subjected to high pressure is economically sound, due to the reasonable first cost of obtaining these hard-faced parts, and due to the greatly reduced maintenance on these parts after installation, as a result of their abrasive resistant properties.

### Results Obtained From Hard Facing

The Pacific Gas and Electric Company has installed needles and throat rings of alloy steel on impulse turbines at three of their structures. At Bucks Creek power house nitralloy parts were installed. At Eldorado and at Stanislaus power house needles and seats of chromium were recently installed. Sufficient time has not elapsed for this company to render a report on the serviceability of these parts as compared to non-hardened parts in these same plants.

The San Joaquin Light & Power Corporation has experimented with stellite. Stellite has been applied to needles and throat rings at the Balch, Crane Valley No. 1 and Tule River power houses. At the Balch plant, the stellited needles and throat rings have been installed for a sufficient period to give an indication of the life of the hard-faced parts as compared to the previously furnished parts manufactured from steel. The steel needles and throat rings at this plant lasted approximately three months, at the end of which time it was necessary to replace them, due to the cutting action of the water. Bronze needles and rings were found to last no longer than the steel.

In January, 1928, at the Balch plant, a stellited 8⅛-in. needle and throat ring were installed. The ring was replaced in February, 1930, when it was decided that a larger diameter throat ring should be installed. The ring, which had been in service for over two years, was found to be in excellent condition.

The Southern California Edison Company Ltd. has had similar experience. At the Big Creek No. 2A plant, stellite needles and throat rings were installed in April, 1929, and appear to be in first class condition after approximately two years of continuous service. Possibly in six months it will be necessary to grind them slightly with a wheel to prevent the fine spray leakage that has developed from wearing the surfaces unduly. It was found that on the units at this plant, as at the Balch plant, bronze and steel nozzle parts would last but three months.

The Southern California Edison Company Ltd. has applied to hydraulic equipment, in addition to stellite, the following alloys: chromium, stoodite, nitralloy and durite.

Chromium plating was applied to needles and throat rings at two stations. The application of this material did not result successfully at either location, due to the plating peeling off in spots, leaving the base metal exposed. It is believed that the reason for this was lack of skill in application, but as both jobs of plating with chromium were unsatisfactory, further attempts at experiment with this particular type of hard facing were abandoned.

Stoodite has been used very successfully. It appears to have the same wearing qualities as stellite. It has been used mainly on parts of considerable area, such as pressure regulator seats and disc, energy absorbers and baffles, although it has been applied to needles and throat rings as well.

Nitralloy needles and throat rings have been recently ordered for use at Big Creek No. 1. This material presents a very good appearance and gives every indication of giving satisfactory service.

Durite needles and throat rings have recently been installed in the nozzles of impulse units at Santa Ana River No. 1 power house. These parts have not been in service long enough to enable a report to be given as to the durability of this alloy.

### Stellite Properties and Method of Application

Stellite is a compound of cobalt, chromium and tungsten. The grade of welding rod which is used for hard-facing material on needles and throat rings has a Brinell hardness of 402. Stellite is usually applied with an oxyacetylene torch. The surface to be stellited is cleaned from oxide or scale by machining or wire brushing and then preheated. The base is preheated to a dull red heat to prevent the stellite surface from developing hair line cracks which are caused by the hard facing contracting at a different rate than the base metal.

The flame for stelliting should contain equal parts of oxygen and acetylene, which differs considerably from the usual ratio of 2½ parts of oxygen to 1 of acetylene, which is used for welding steel to steel. When applying the stellite, a small area of the steel is brought to a sweating heat by means of the torch. At this heat the steel is at about 2,100 deg. F., or at a point where the surface is just beginning to form globules of molten metal on the surface. The stellite rod is then melted down and is forced to spread by being pushed with the welding rod. Care must be taken to blow slag off the molten metal while welding successive areas. The slag left in the metal is responsible for the pin holes found in the hard facing after grinding.

The stellite will not puddle with the steel and a layer of approximately 3/16 in. is applied in order to leave at least 1/16 in. of finished hard facing after grinding. The Southern California Edison Company Ltd. has applied three coats of stellite to needle tips and throat rings. One coat appears, from results to date, to give all that is required in the way of protection. Care must be taken to allow sufficient metal for grinding to a finished surface.

Stellite is applied in a spiral around the needle tip to be stellited in a band about an inch wide. It takes the same amount of time as brazing would under similar conditions.

### Properties of Stoodite and Method of Application

Stoodite is supplied in the form of a welding rod and has been used to some extent by the Southern California Edison Company Ltd. An electric arc can be used in its application and it apparently is more susceptible to gas pockets which are uncovered upon grinding. Pockets in both stoodite and stellite do not appear to enlarge with usage. The harmful effect of these pockets is caused by their occurence at the needle valve seat on the needle or ring. Stoodite has been used with marked success with electric arc to fill pockets found in the stellite facing upon grinding. The stoodite so placed adheres with the stellite and forms a homogeneous material that can be ground to a smooth surface. Stoodite has a Brinell hardness of 540. This figure is increased if the stoodite is applied with a torch.

When stoodite is applied with the arc, the base metal is usually not preheated. When the torch is used, the alloy is applied in the same manner as stellite.

On both stoodite and stellite, a 14-in. grinding wheel is used and run at a speed of 1,800 r.p.m.

### Properties of Nitralloy and the Nitriding Process

Nitralloy is an alloy steel of special properties that becomes hard when heated and subjected to ammonia gas. This process is called nitriding. Nitralloy steel is manufactured in several different grades and designated according to the carbon content. It contains aluminum, chromium and molybdenum. With this alloy, the part to be hardened can be machined to finished dimensions, making expensive and laborious grinding unnecessary. After the machining is accomplished, the part is placed in an electric furnace, the temperature of which can be closely controlled from 950 deg. F. to 1,100 deg. F. The desired concentration of ammonia gas is admitted to this inclosed furnace and the part treated for the period desired. The nitrided case after a full 90-hr. period is approximately 0.031 in. deep. The Brinell hardness of this case will vary from 1,000 on the surface to 378 at the 0.031-in. depth.

### Properties of Durite

Durite is a high-carbon electric steel containing chrome and vanadium. When cast and annealed it has a Brinell

TABLE I—Cost of Impulse Turbine Parts of Special Alloys.

| Plant | Static Head (ft.) | Part | Work | Material | Cost |
|---|---|---|---|---|---|
| Balch | 2,381 | 8 1/16-in. needle and throat ring | Surfacing | Stellite | $170.36 |
| Big Creek No. 2A | 2,419 | 9 7/16-in. needle and throat ring | Surfacing | Stellite | 219.00 |
| Big Creek No. 1 | 2,131 | 7 3/16-in. needle and throat ring | Surfacing | Stellite | 216.00 |
| Santa Ana River No. 1 | 726 | 6 11/16-in. needle and throat ring | Cast, machine and treat | Durite | 100.00 |
| Big Creek No. 1 | 2,131 | 9 7/16-in. needle and throat ring | Cast, machine and treat | Nitralloy | 165.00 |
| Bucks Creek | 2,562 | 8 1/16-in. needle and throat ring | Forge, machine and treat | Nitralloy | 177.00 |
| Eldorado | 1,910 | 8 1/16-in. needle and throat ring | Forge, machine and treat | Nickel chrome | 111.00 |
| Stanislaus | 1,498 | 6 3/4-in. needle and throat ring | Forge, machine, plate | Chromium plate | 145.00 |
| Original Cost of Impulse Turbine Parts Untreated | | | | | |
| Balch | 2,381 | 8 1/16-in. needle and throat ring | Forging, machining | Steel | $261.00 |
| Big Creek No. 2A | 2,419 | 9 7/16-in. needle and throat ring | Forging, machining | Steel | 273.00 |
| Big Creek No. 2A | 2,419 | 9 7/16-in. needle and throat ring | Casting, machining | Bronze | 272.00 |

In all cases, sizes of needles and throat rings refer to actual diameter of ring and not to jet diameter.

of 210 and can be machined very easily with carboloy. After machining and polishing to size, the casting is quenched in oil between temperatures of 200 deg. F. to 1,300 deg. F. Each 100 deg. F. of draw alters the physical properties so that hardness from 230 to 600 Brinell may be obtained. At this higher draw the hardness extends throughout the casting, having an advantage over nitralloy in this respect.

The ultimate strength of the material is 285,000 lb. per sq.in. with a yield point of 260,000 lb. per sq.in. The material has practically no ductility, but its very high yield point indicates its great strength.

As yet no report can be made on the wearing qualities of this material, due to the short time it has been installed.

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# *Current Practice and Research in Hydro Development**

*The principal function of this committee is to find where any research or investigation is being made by the operating companies, what new developments in engineering or operating methods are being used or developed and to serve as a clearing house for this information to the end that all member companies can directly benefit from the collective experience of all.*

*This subcommittee was first formed with E. N. Murphy as chairman during the year 1928-29, but dealt only with the subject of research. Under R. M. Peabody in 1929-30 the subject of current practice was added to its duties.*

*This information is collected continuously, it being unnecessary to wait until any study is completed before the data are made available.*

INVESTIGATIONS which have been made and previously reported are as follows:

*A. Bureau of Power and Light—City of Los Angeles*
(1) Tests on paints and protective coatings, San Francisquito penstock.

*B. City of San Francisco—Hetch Hetchy Aqueduct*
(1) Decrease in flow capacity of Hetch Hetchy tunnel.

*C. Pacific Gas and Electric Company*
(1) Test of 24-in. diameter butterfly valve under free discharge. (Operating torque and coefficient of discharge.)
(2) New types of riveted joints for penstocks.
(3) Longitudinal reinforcement for concrete flumes.
(4) Determination of flow coefficient (Drum penstock) for steeple head riveted and for countersunk riveted pipe.
(5) Protective coatings on Spaulding No. 3 penstock.

*D. San Joaquin Light & Power Corporation*
(1) Grouting details on Balch dam.
(2) Operating control features for penstock valve.
(3) Determination of discharge coefficient for 22-in. diameter needle valve at Balch afterbay dam.
(4) Determination of flow coefficient—Balch penstock.

*E. Southern California Edison Company Ltd.*
(1) Pressure rise in penstock due to emergency closing of penstock valves.

*F. Southern Sierras Power Company*
(2) Use of mercury gage for determining water levels in Hillside reservoir.

The following information, which is included in detail in this report, has been added during the past year.

PACIFIC GAS AND ELECTRIC COMPANY

*A. Research*
(1) Experimental protective coatings on metal flumes—Drum Canal. Tests under way; no conclusions yet.
(2) Measurement of concrete temperatures at Lyons dam.
(3) Inspection of protective coatings—Spaulding No. 3 penstock.
(4) Test of 8-in. Barfoed free discharge valve, made in co-operation with Joshua Hendy Company.

*B. Current Practice*
(1) Outlet works for Salt Springs dam.
(2) Use of a through baffle for dissipating the energy from a free discharge needle valve.
(3) Use of copper contraction joints in Tiger Creek reinforced concrete flume to reduce amount of longitudinal reinforcing steel.
(4) Automatic protective devices for Tiger Creek conduit.
(5) Use of new Kellogg seamless pipe for a portion of Tiger Creek penstock.
(6) Tiger Creek generating equipment utilizes a new design of "straight-flow" nozzle and resumes the use of a stream bender for deflecting the jet when load is rejected. Electrical connections have likewise been simplified as described in more detail later in the report.

SAN JOAQUIN LIGHT & POWER CORPORATION

*A. Current Practice*
(1) Description of automatic load control equipment used at Merced Falls plant.
(2) Radial gate for Merced Falls.
(3) Sluiceway for disposition of trash at intake.

SOUTHERN SIERRAS POWER COMPANY
(1) Use of a grinding stone for polishing collector rings of generator.
(2) Use of mercury gage at Gem Lake.

SOUTHERN CALIFORNIA EDISON COMPANY LTD.
(1) Operating experience and alteration of draft tube at Big Creek No. 3.

## *Research*

### INSPECTION OF PROTECTIVE COATINGS—SPAULDING NO. 3 PENSTOCK[1]

These coatings were inspected in May, 1930, after nearly two years of service. The results of the inspection are as follows:

*A. Exterior Coatings*
(1) *Bitulumin over gray iron primer*—This coating is in excellent condition with no evidence of deterioration except rust spots at leaky rivets.
(2) *Aluminum in water gas tar over water gas tar primer*—Condition generally very good. Some alligatoring, mostly below the horizontal diameter.

*B. Interior Coatings—(All coatings eroded on bottom due to gravel)*
(1) *Bitulumin over gray iron primer (Section L)*—Condition very good. Occasional rust spots which, however, still show aluminum paint beneath when scraped off.

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* Report of subcommittee on current practice and research, hydraulic power committee, Engineering Section. W. Dreyer, chairman. C. L. Davis, C. V. Foulds, J. W. Jourdan, R. F. Krafft, L. T. McAffee, R. M. Peabody, R. R. Robertson, C. P. Vetter.

[1] Report submitted by Pacific Gas and Electric Company.

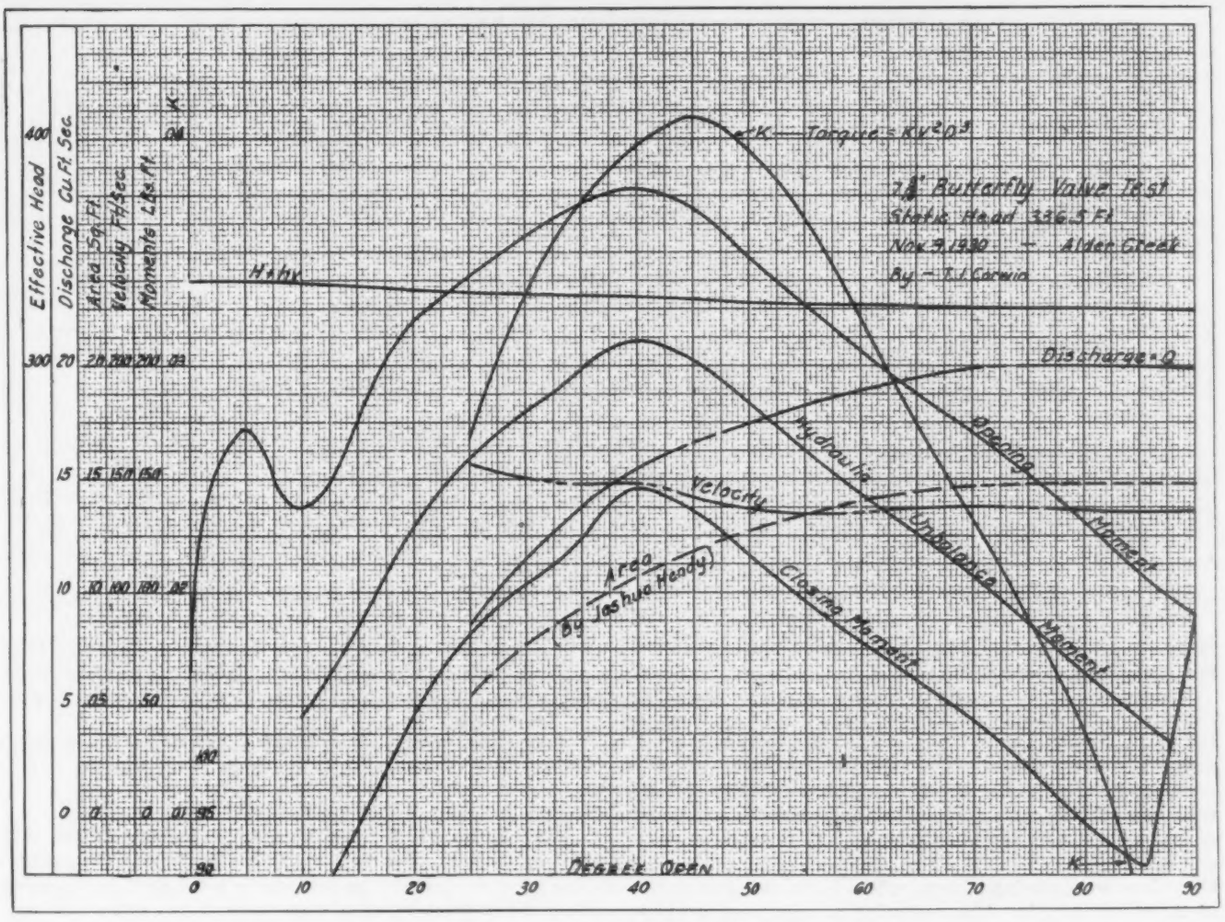



*Fig. 1. Tests on Borfoed valve.*

(2) *Coal gas tar thinned with still bottoms and applied over water gas tar (Section M)*—Condition excellent. No rust spots except where paint has been eroded off bottom. Coating is considerably thinner than those applied hot.

(3) *Water gas tar and aluminum over water gas tar primer (Section N)*—Condition excellent. Coating relatively thin compared to hot coatings.

(4) *Coal gas tar over water gas tar primer (Applied hot)*—Section O is very good on top as well as sides, there being some checking, but no separation. Other sections (P, I and 3-J) show considerable sag near horizontal diameter, but condition is generally excellent below the horizontal diameter. Above the horizontal diameter there is considerable amount of alligatoring, the coating pulling apart from ¼ to ½ inch in most cases, and as much as 1 inch in a few places. At these points the coal tar has pulled down so thin that it is difficult to distinguish it from the primer coat of water gas tar.

(5) *Biturine enamel over Biturine primer (Section K and 3-J)*—This coating generally in excellent condition except for checking on the top 1/5 to 1/4 of circumference, which cracks on longitudinal lines. These cracks show rust as though this coating was being lifted off, but on cutting with knife, it cannot be pried off and the crack does not generally extend clear through to metal. There is some sagging near the horizontal diameter, but not quite to the same extent as the coal tar. If a more flexible coating could be applied over the enamel on the top quarter of the pipe, the coating would be 100 per cent. It may be advisable to apply a thin coat of either the priming solution or an enamel with a lower melting point, to obtain a perfect job.

*Remarks*: All of the interior and exterior coatings are generally in excellent shape. The interior coatings have all been eroded on the bottom of the pipe due to gravel and sand and this section naturally shows rust. Aside from this portion and the few rust spots on the interior Bitulumin and in the checks of the coal tar and enamel, no rust or tubercles were noticed in the sections examined. (Station 5 + 54 to 9 + 34.)

### Test on Barfoed Free Discharge Valve[1]

The Joshua Hendy Company, co-operating with Pacific Gas and Electric Company, tested a 7½-in. diameter free discharge Barfoed valve at the Alder Creek siphon on the El Dorado canal. The static head at this point is 336 ft.

The results of the tests are shown graphically in Fig. 1. It will be noted when compared with free discharge butterfly valves of a standard type that the operating torque as indicated by the value of "K" is reduced from about 0.09 to 0.04 and maximum torque occurs at about 45 deg. angle rather than near the full open position. There is also an increase in the coefficient of discharge over that obtained in previous tests.

[1] Report submitted by Pacific Gas and Electric Company.

## *Current Practice*

In the field of current practice, the following are some of the features now being installed on the Mokelumne River project of the Pacific Gas and Electric Company:

*Pacific Gas and Electric Company*

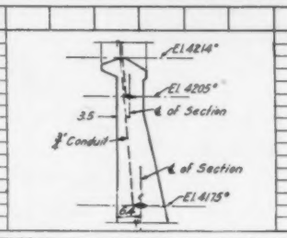
### Outlet Works for Salt Springs Dam

In view of the importance and great size of this structure, it is considered advisable to provide for possible emergency unwatering of the reservoir. Two 78-in. diameter free discharge butterfly valves are being provided for this purpose. The combined capacity of these valves and the power house

FIG. 2. CONCRETE TEMPERATURES, LYONS DAM, PACIFIC GAS AND ELECTRIC COMPANY

| SECT. | DATE POURED | ELEV. | TEMPERATURE READINGS DATES SHOWN BELOW | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 11/27/29 | 11/29 | 11/30 | 12/1 | 12/4 | 12/9 | 12/11 | 12/18 | 12/19 | 12/20 | 12/21 | 12/22 | 12/23 | 12/24/29 | 1/1/30 | 1/2 | 1/3 | 1/8 | 1/15 | 1/22 | 1/29 | 2/4 |
| 3L | 11/28/29 | 4186 | - | 29.0 | 105.5 | 112.5 | 113.0 | 102.5 | 99.5 | 88.0 | - | - | - | - | - | 80.0 | 70.0 | 69.0 | 68.0 | 59.5 | 57.0 | 55.0 | 49.5 | 47.0 |
| 3U | - | 4205 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 40.0 | 40.0 | 39.0 | 42.0 |
| 4L | 11/23/29 | 4184 | 97.5 | - | 102.5 | - | 102.0 | 92.0 | 88.5 | - | - | - | - | - | - | - | 61.0 | - | - | 56.5 | 51.0 | 48.0 | 46.0 | 45.5 |
| 4U | - | 4205 | - | - | - | - | - | | | | | | | | | | | | | - | - | | | |
| 5L | 11/19/29 | 4175 | 116.0 | - | 113.0 | - | 106.5 | 95.0 | 92.0 | 82.0 | - | - | - | - | - | 75.0 | 66.0 | - | - | 60.0 | 53.0 | 48.5 | 46.5 | 45.0 |
| 5U | 12/ 5/29 | 4205 | - | - | - | - | - | 69.5 | 68.5 | 70.5 | - | - | - | - | - | 58.5 | 56.0 | - | - | 44.5 | 43.0 | 38.0 | 36.0 | 38.5 |
| 6L | 11/14/29 | 4175 | 101.0 | - | 98.0 | - | 85.0 | 78.0 | 75.5 | 68.5 | - | - | - | - | - | 62.5 | 59.0 | - | - | 44.5 | 43.0 | 40.0 | 38.0 | 39.0 |
| 6U | 12/ 7/29 | 4205 | - | - | - | - | - | 72.0 | 69.0 | 54.5 | - | - | - | - | - | 61.5 | 57.5 | - | - | 49.5 | 43.0 | 34.5 | 35.5 | 37.5 |
| 7L | 11/21/29 | 4175 | 114.0 | - | 109.0 | - | 101.5 | 90.5 | 86.0 | 75.0 | 72.0 | 72.0 | - | - | - | 67.0 | 64.0 | - | - | 53.5 | 42.0 | 39.5 | 38.5 | 38.0 |
| 7U | 12/18/29 | 4205 | - | - | - | - | - | - | - | - | 71.0 | 74.0 | - | - | - | 65.5 | 65.0 | - | - | 56.5 | 39.5 | 38.5 | 38.0 | 40.0 |
| 8L | 11/16/29 | 4175 | 99.0 | | 94.5 | | 86.0 | 79.0 | 93.5 | 69.0 | | | | | 64.0 | 63.0 | 55.0 | - | - | 48.5 | 42.5 | 39.5 | 38.0 | 37.0 |
| 8U | 12/22/29 | 4205 | - | - | - | - | - | - | - | - | - | - | - | - | 54.5 | 58.0 | 69.0 | - | - | 55.5 | 39.5 | 37.5 | 36.0 | 38.0 |
| 9L | 11/21/29 | 4175 | 115.5 | - | 115.5 | - | 110.0 | 101.0 | 91.3 | 86.0 | -. | 83.0 | 86.0 | 81.0 | - | 78.0 | 68.0 | - | - | 61.0 | 53.5 | 48.0 | 35.0 | 43.0 |
| 9U | 12/20/29 | 4205 | - | - | - | - | - | - | - | - | - | 65.5 | 71.5 | 74.0 | - | 71.0 | 51.0 | - | - | 41.0 | 30.5 | 34.0 | 35.0 | 36.0 |
| 10L | 11/22/29 | 4179 | 105.5 | - | 114.5 | - | 110.0 | 100.9 | 95.0 | 82.0 | - | - | - | - | - | 72.0 | 62.5 | - | - | 52.0 | 50.0 | 46.0 | 41.5 | 41.5 |
| 10U | 12/ 7/29 | 4205 | - | - | - | - | - | 102.0 | 96.0 | 73.0 | - | - | - | - | - | 55.5 | 42.0 | - | - | 35.5 | 26.0 | 30.0 | 32.0 | 33.0 |

| SECT. | 2/12 | 2/19/30 | 2/27 | 3/6 | 3/12 | 3/19 | 3/26 | 4/3 | 4/12 | 4/21 | 5/1 | 5/13 | 5/24 | 6/3/30 | 2/20/31 | 3/17/31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3L | 48.5 | 46.0 | 47.0 | 45.0 | 45.0 | 45.0 | 44.5 | 44.0 | 44.5 | 44.0 | 45.0 | 45.0 | 45.0 | 46.0 | 49.9 | 54.8 |
| 3U | 44.0 | 43.0 | 40.5 | 38.5 | 40.0 | 39.5 | 44.0 | 47.0 | 49.0 | 50.0 | 49.0 | 46.5 | 53.5 | 54.0 | 40.7 | 40.3 |
| 4L | 45.5 | 46.0 | 46.0 | 44.5 | 44.0 | 44.0 | 44.0 | 46.0 | 47.0 | 48.0 | 49.5 | 48.5 | 49.5 | 51.0 | 44.4 | 40.8 |
| 4U | | | | | | | | | | | | | | | 41.2 | 42.0 |
| 5L | 45.0 | 46.0 | 46.5 | 44.5 | 44.0 | 44.5 | 45.0 | 48.0 | 51.0 | 52.5 | 55.0 | 53.0 | 54.0 | 54.5 | 42.4 | 40.0 |
| 5U | 41.0 | 44.0 | 39.0 | 37.0 | 39.5 | 39.5 | 45.5 | 50.0 | 52.5 | 53.0 | 51.5 | 47.5 | 54.5 | 55.5 | 38.3 | 43.6 |
| 6L | 46.0 | 43.5 | 42.0 | 40.5 | 40.0 | 41.0 | 45.5 | 46.0 | 50.0 | 51.0 | 54.0 | 51.5 | 55.0 | 53.5 | 38.0 | 42.9 |
| 6U | 40.0 | 43.5 | 39.0 | 37.5 | 39.0 | 39.0 | 45.0 | 49.5 | 53.5 | 53.5 | 52.5 | 48.1 | 55.0 | 56.0 | 39.0 | 45.6 |
| 7L | 38.5 | 40.0 | 40.0 | 38.5 | 38.5 | 39.0 | 40.5 | 45.0 | 48.0 | 50.0 | 52.0 | 51.5 | 53.0 | 53.0 | 37.9 | 43.4 |
| 7U | 42.0 | 45.0 | 40.0 | 38.5 | 40.5 | 40.5 | 46.0 | 51.0 | 55.0 | 55.0 | 54.0 | 50.0 | 57.0 | 57.5 | 39.6 | 44.2 |
| 8L | 37.5 | 38.5 | 39.0 | 37.5 | 37.5 | 38.5 | 42.0 | 44.0 | 47.0 | 49.0 | 51.5 | 49.0 | 50.5 | 50.5 | 34.3 | 46.5 |
| 8U | 40.0 | 43.5 | 38.0 | 37.0 | 39.5 | 38.5 | 45.5 | 49.0 | 53.0 | 53.5 | 51.0 | 48.0 | 55.5 | 55.0 | 37.1 | 43.7 |
| 9L | 42.5 | 42.5 | 42.5 | 41.0 | 40.5 | 40.5 | 41.0 | 44.5 | 47.0 | 49.5 | 52.0 | 50.5 | 51.5 | 52.0 | 36.0 | 46.5 |
| 9U | 38.5 | 41.5 | 35.5 | 34.0 | 38.0 | 38.5 | 45.5 | 50.5 | 55.0 | 55.5 | 53.0 | 49.0 | 57.0 | 56.5 | 37.3 | 46.8 |
| 10L | 41.0 | 41.0 | 40.0 | 38.5 | 38.0 | 37.5 | 37.5 | 36.0 | 40.0 | 38.0 | 40.0 | 39.0 | 41.5 | 42.5 | 34.8 | 51.2 |
| 10U | 36.0 | 39.0 | 36.0 | 34.5 | 36.0 | 35.5 | 40.5 | 44.5 | 49.0 | 50.0 | 49.0 | 45.0 | 52.5 | 52.0 | 36.2 | 48.1 |




is about 7,000 sec.-ft. The free discharge valves will be mechanically operated.

The shut-off valves for the installation are two 10-ft. 9-in. diameter butterfly valves located at the downstream end of the 19-ft. diameter tunnel under the right abutment of the dam. The operation of these valves is hydraulic, using oil under 1,200-lb. pressure and utilizing two opposed cylinders with rams rather than the conventional piston and cylinder. A dead weight accumulator will be used to maintain pressure on the oil system, there being a sufficient supply of pressure oil to insure the closing of both valves in the event of failure of the power supply. The operating arrangement is shown diagrammatically in Fig. 3.

### SALT SPRINGS POWER HOUSE

It is necessary to install a bypass valve at Salt Springs power house to provide for the diversion of water into Tiger Creek conduit. It is planned to dissipate the energy of the jet, which discharges vertically from a 57-in. diameter needle valve under 280-ft. head, by means of a through baffle which was developed by Mr. Gfeller of the Southern California Edison Company.

### TIGER CREEK CONDUIT

The conduit for the Tiger Creek project is in the main a reinforced concrete bench flume. As a result of the study on longitudinal reinforcement requirements, which was previously reported to this subcommittee, it was decided to use a nominal amount of reinforcement and install copper joints rather than make the reinforcing steel continuous and 0.6 per cent in quantity. It is estimated that a saving of $1.50 per lin. ft. of flume is accomplished by this procedure.

Automatic protective features for Tiger Creek conduit will consist of siphon spillways arranged in batteries of two or more below all feeder canals. Just below Salt Springs power house a float-operated and controlled radial headgate will be provided to protect the flume from receiving more water than it can safely accomodate. At Tiger Creek regulating reservoir a fluctuation of about 18 ft. in depth may be expected daily. The gate at the entrance to the conduit leading from the regulator will be motor operated and automatically controlled to deliver to this conduit any predetermined quantity of water. The control for this gate will be of the type described in the report of Mr. Crellin's committee on "Automatic Hydraulic Regulatory and Safety Devices."

In addition to this control, a float-operated and controlled radial check gate similar to that at Salt Springs power house will be installed a short distance downstream from the head gate. This gate is to function as a protective feature in the event of maloperation or interruptions to the power supply to the headgate.

A similar arrangement will be used at Tiger Creek afterbay for diverting water into the West Point conduit.

### TIGER CREEK PENSTOCK

The feature of greatest interest is the use of the new Kellogg seamless pipe for the lower 700 ft. of the penstock. This product is made by piercing a billet and then placing the pierced billet between cross-rolls which reduce the wall thickness down to the specified amount, maintaining the length constant.

The solid ingots are about 5 ft. long and approximately 3 ft. in diameter, being octagonal or hexagonal in shape. These billets are heated to 2,000 deg. F. and a 26-in. to 29-in. diameter hole is formed by means of a 10,000-ton hydraulic press. The hot metal is extended along the sides until the length of the billet becomes about 10 ft. The hollow tube is machined to a clean surface and to the required diameter. This heavy-walled tube, 36-in. outside diameter, by 10-ft. length with walls 4-in. to 5-in. thick, is then heated to about 2,300 deg. F. and rolled to an outside diameter of about 54 in. It is then reheated to 1,500 deg. F. and rolled to the required diameter. Scale formed during the rolling process is largely removed by means of steam.

For Tiger Creek the shop round seams are of a modified bump type with a flat angle, although it is likely that on future work this joint may be formed by electric welding. Field seams are made with seamless butt straps, the pipe and butt strap being machined on a slight taper to facilitate erection.

Another feature of this installation is the use of a single pipe line branching first into two and finally into four lines at the power house. It is estimated that a saving of about $150,000 resulted by using one instead of two pipes.

### TIGER CREEK GENERATING EQUIPMENT

No new or radical changes in power house equipment have been incorporated in the design of the Tiger Creek power house, but a few relatively new ideas have been adopted and will probably become standard for future plants of similar nature.

Water is delivered to the wheel through a "straight-flow" nozzle body of new design. The "straight-flow" principle is recognized as desirable in increasing the wheel efficiency and

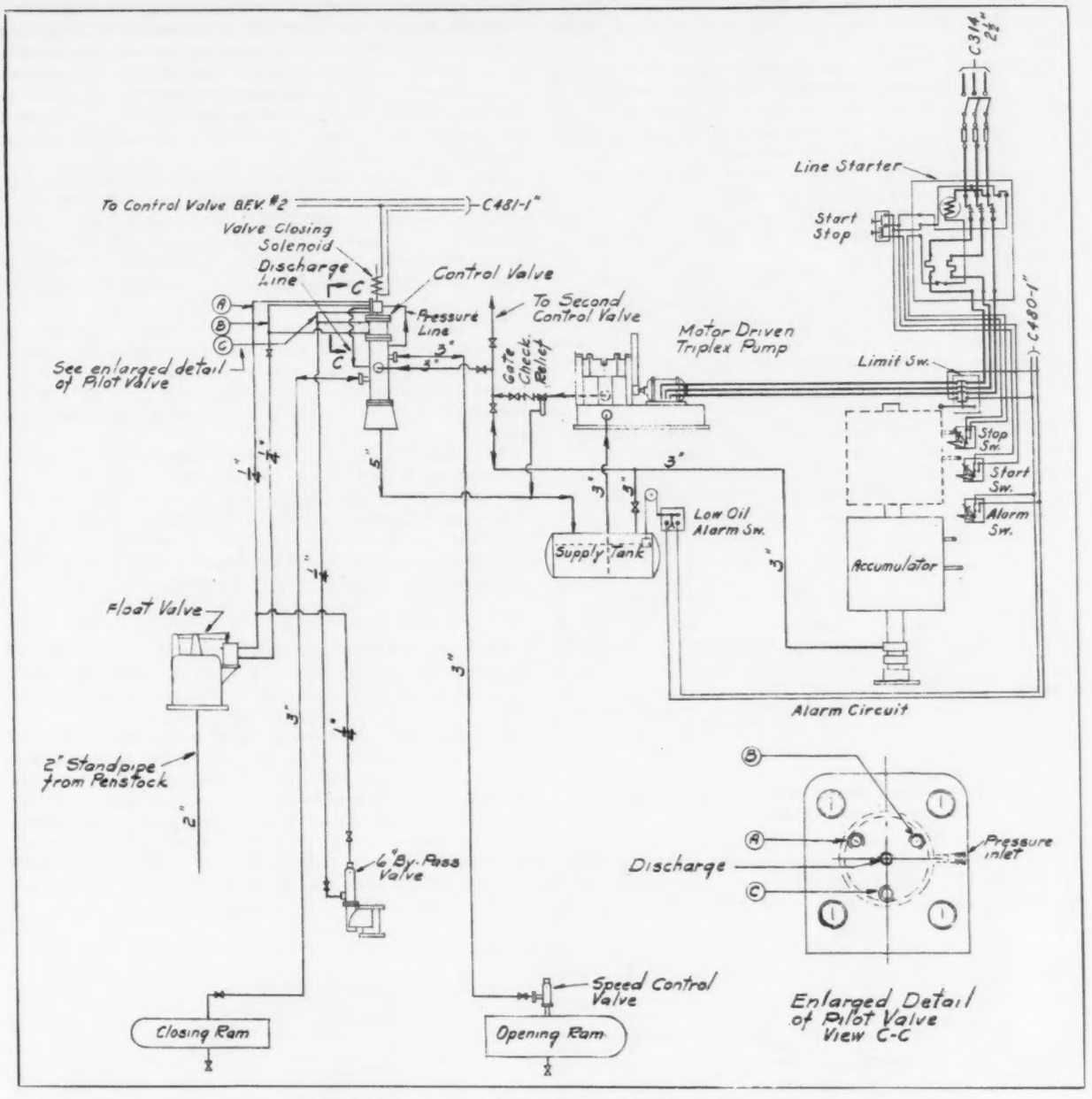



*Fig. 3. Diagram of oil piping for one valve Salt Springs dam.*

nozzles of this type were installed at Big Creek power house No. 2A and on the fourth unit in Drum power house. The latest installation contains a few refinements in design calculated to give better operation in service. It seems likely that the "straight-flow" nozzle will entirely replace the old "S" type on large units.

The old idea of a stream bender to deflect the jet from the wheel on sudden load rejection has been revived at Tiger Creek. This method offers several advantages over the auxiliary needle or relief valve when the feature of slow needle closures is added as a water conserving measure, the principle advantage being the possibility of exceptionally fast governor action and freedom from water hammer. The pressure rise due to closing gates was reduced from about 200 ft. to 50 ft. at the power house with a considerable saving in penstock costs.

Main electrical connections have been reduced to the simplest possible arrangement, with no oil circuit breaker between the generator and its transformer. Trouble will be cleared on the high side breaker. The idea of considering the generator and transformer as a single unit is gaining popularity and results in simplified operation. Occasionally trouble is experienced in carrying the heavy currents from large generators through oil circuit breaker contacts and this has added a further incentive toward the elimination of breakers from the main generator leads.

*San Joaquin Light & Power Company*

### Automatic Load Control Equipment for Merced Falls Unit

The main element present in the problem of automatic load control for the Merced Falls unit was the necessity of delivering all of the water that entered the pond to the irrigation system below at the same rate it entered the pond, necessitating close regulation of the pond level, and at the

same time of using all of that water possible through the turbine with provision for bypassing any excess. It is essential that a constant pond level be maintained.

By adjusting the opening of the wicket gates of the turbine in accordance with small changes of pond level, the conditions outlined above can be met for flows of water up to the capacity of the turbine, approximately 2,200 sec.-ft. Flows in excess of the turbine capacity are taken care of by diverting the excess through a radial gate on the spillway crest of the dam. The operation of the radial gate is similar to that of the wicket gates, but it is adjusted to start opening when the pond level continues to rise with the wicket gates wide open.

The device for regulating the wicket gates, as shown by the accompanying wiring diagram (Fig. 4) consists of three main elements, namely, the float mechanism and regulator H, the transmitter G, and the control motor F that operates the servo-motor which in turn actuates the wicket gates.

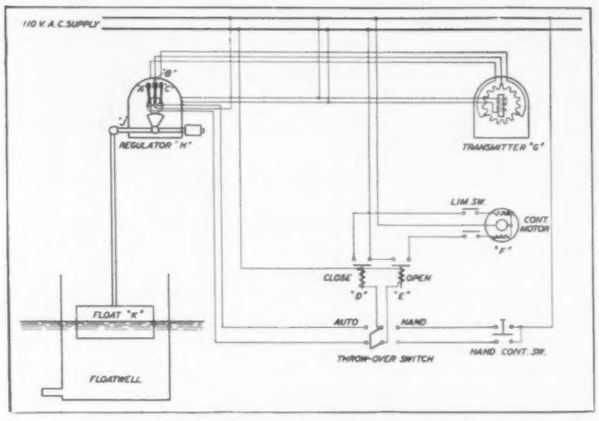



*Fig. 4. Automatic load control equipment for Merced Falls power plant.*

The regulating system operates on the self-synchronous motor principle. The transmitter G is linked to the gate operating equipment and is provided with suitable internal gearing to rotate the rotor through an angle of slightly less than 180 deg. for full travel of the wicket gates. The regulator H is similar to the transmitter but has the addition of the contact arms A, B, and C, and the float mechanism. The contact arm B is connected to the lever J which in turn is connected to the float K. A 0.3-ft. change in pond level causes the contact arms A and C to rotate through an angle of slightly less than 180 deg.

A change in water level causes contact to be made between A and B or C and B. This energizes the control motor F through the low current pilot relays D or E, causing the wicket gates to move in the required direction. The movement of the gates operates the transmitter G which transmits the motion back to the contact B which breaks with A or C and the gate comes to rest.

The regulating equipment provides a reliable follower system and will accurately adjust the wicket gates in response to changes of pond level. At present the equipment is adjusted to operate on a 0.3-ft. change in pond level which practically meets the conditions outlined in the first paragraph.

The automatic radial gate is 13 ft. high by 20 ft. wide and its capacity is 3,300 sec.-ft. In addition to this gate, there are two motor-operated gates, each of 3,300 sec.-ft. capacity. The total spillway capacity is approximately 60,000 sec.-ft. including the discharge of the turbine and 540 ft. of the dam crest controlled by timber needles 9 ft. high and supported nearly vertically by steel frames.

## Radial Gate Seals—Merced Falls Plant

The three 13 x 20-ft. steel radial spill gates are sealed with special rubber sealing strips. Two of the gates are motor-operated by means of a common hoist capable of being shifted from one gate to the other. These two gates are provided with side sealing seats consisting of galvanized steel channels. The third gate, which is designed for automatic float control, is provided with steel channel side seats (not galvanized), equipped with Monel metal sealing strips. All three gates seat on galvanized steel channel sills. Galvanizing the side channels of the two motor-operated gates, which will be used infrequently, is believed to be sufficient to prevent corrosion of the steel channels and consequent sticking and possible deterioration of the rubber seals.

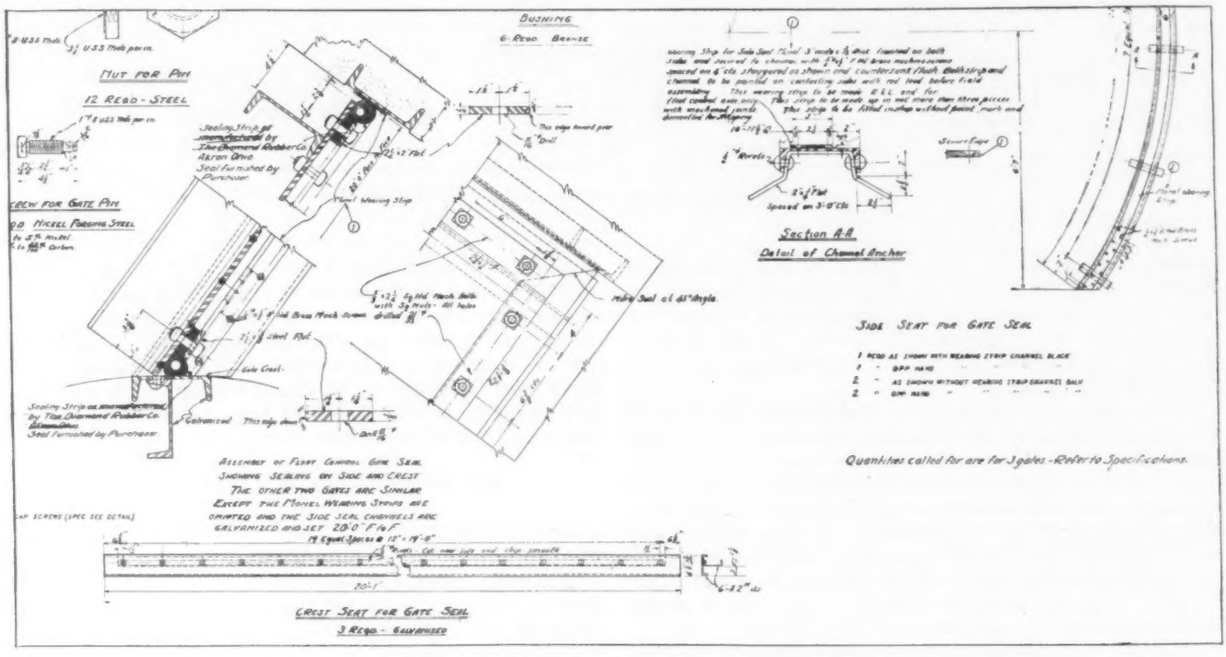

BUSHING
6 REQD. BRONZE
NUT FOR PIN
12 REQD - STEEL
CROW FOR GATE PIN
Section A-A
Detail of Channel Anchor
SIDE SEAT FOR GATE SEAL
Quantities called for are for 3 gates - Refer to Specifications.
ASSEMBLY OF FLOAT CONTROL GATE SEAL
SHOWING SEALING ON SIDE AND CREST
THE OTHER TWO GATES ARE SIMILAR
EXCEPT THE MONEL WEARING STRIPS ARE
OMITTED AND THE SIDE SEAL CHANNELS ARE
GALVANIZED AND SET 20'-0" F to F
CREST SEAT FOR GATE SEAL
3 REQD. - GALVANIZED

*Fig. 5. Radial Gate Details, Merced Falls dam.*

The automatic gate is operated frequently and it was therefore decided to use the Monel metal side strips as described above, to prevent undue wear of the rubber seals. Bronze sealing strips would probably accomplish the same purpose as the Monel metal, but would probably not resist so well the corrosive action of the water in the pond, which is used for a mill pond as well as a forebay.

### Sluiceway for Disposing of Trash at Intake

In spite of measures taken by the saw mill operators to prevent waste material from coming down the pond, a considerable amount of trash, consisting of bark and scrap wood, lodges at the intake. The trash is raked off the rack bars by hand, and disposed of hydraulically by means of a receiving hopper built of concrete, and 208 ft. of ¼ x 24-in. welded steel pipe. The pipe is laid on a grade of 0.75 ft. per 100 ft. in back filled trench under the power house and beyond to the point of disposal, where the trash is dried out and burned. The pipe line is laid with one horizontal bend of 36 deg. on a radius of 100 ft. The bend is confined to four 16-ft. straight lengths of pipe with ends cut to the proper angle and welded together. All field joints were acetylene welded. The pipe was hot dipped in a Biturine product at the factory.

A 12-in. valve is used to discharge water from the forebay pond into the hopper in quantities depending upon the amount of trash being sluiced. During the eight months of operation of plant this method of trash removal has proved entirely satisfactory, and has resulted in saving the inconvenience and expense of hauling the trash away in trucks.

Fig. 6 shows details of the hopper.

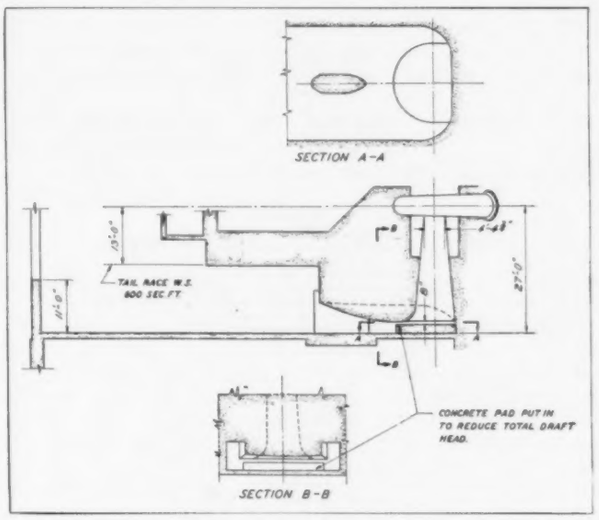



*Fig. 6. Hopper for trash rack, sluice pipe.*

*Southern Sierras Power Company*

### Grinding of Collector Rings on Generators

C. L. Davis submits the following:

"We have been having more or less trouble with the steel collector rings on generators getting rough, due to their continual use, which has caused us to have to resort to turning them down with special tools and has necessitated taking the generator out of service. Recently, however, the idea came to our mechanical force to substitute a grinding stone in the position of one of the carbon brushes.

A carefully selected stone was cut to the proper dimensions to fit in the holder for one of the brushes, and was substituted for this brush, and has resulted in several instances in our obtaining an excellent surface on the rings without the necessity of grinding or turning down of the rings.

Several things have come into this method of treatment, which deserve consideration. Naturally the condition of the collector ring cannot be allowed to develop to a very poor condition before the stone is used, otherwise the ring will

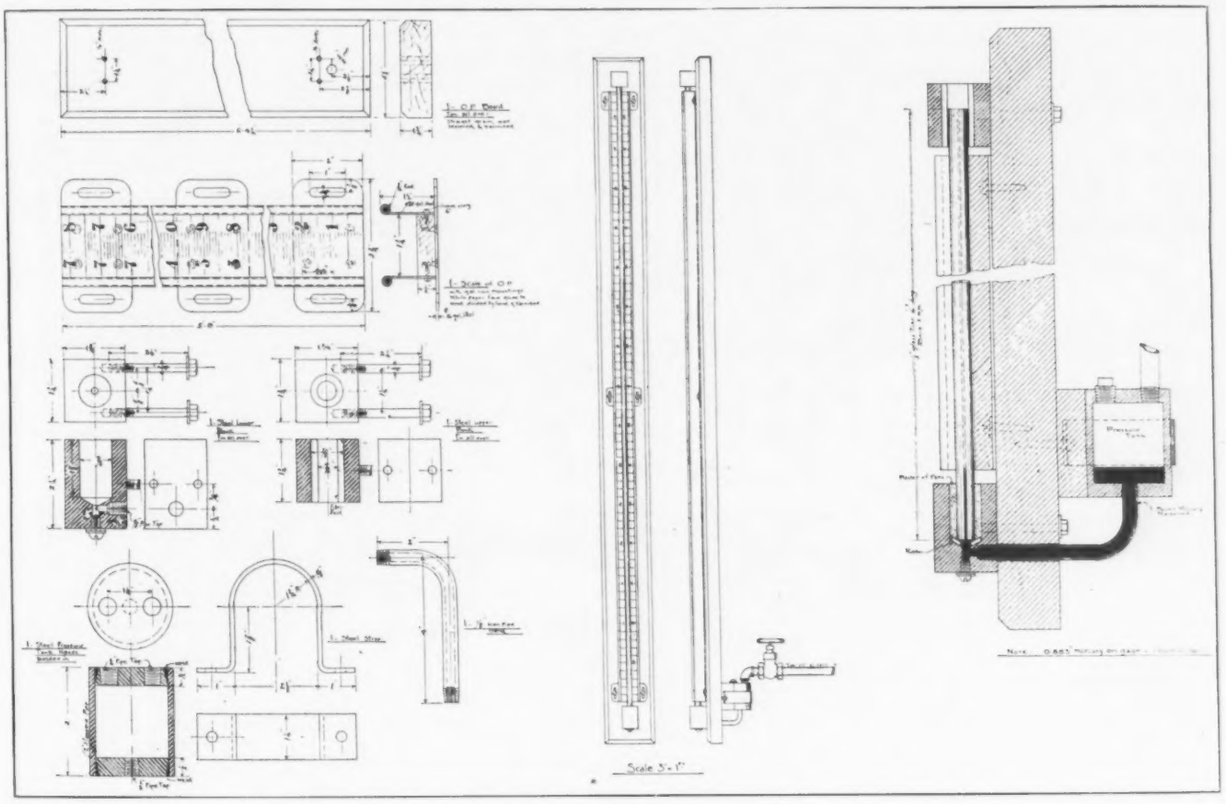


*Fig. 7. Mercury column reservoir gage.*

be worn eccentric; also a careful selection of the stone must be made, depending upon the speed and several other considerations of similar importance. Again, this stone must be removed immediately when a good surface has been developed. The stone cannot be left in place continually without unnecessary wear on the ring. We have further found the best service by putting the stone in place of the trailing brush on the rings, so that the dirt and grinding originating from the grinding of the stone will not affect the brushes in the other holders on this same ring.

I have not yet tried similar methods on bronze collector rings, but I have no doubt that with the proper selection of the stone and the judicious use of same, similar results might be obtained just as easily on bronze."

Mr. Bragg of the Pacific Gas and Electric Company reports as follows on this subject:

"Most of the collector rings of the Pacific Gas and Electric Company are made of either bronze or cast iron. When unsatisfactory operation of brushes on the collector rings is experienced, the brushes are usually changed by substituting

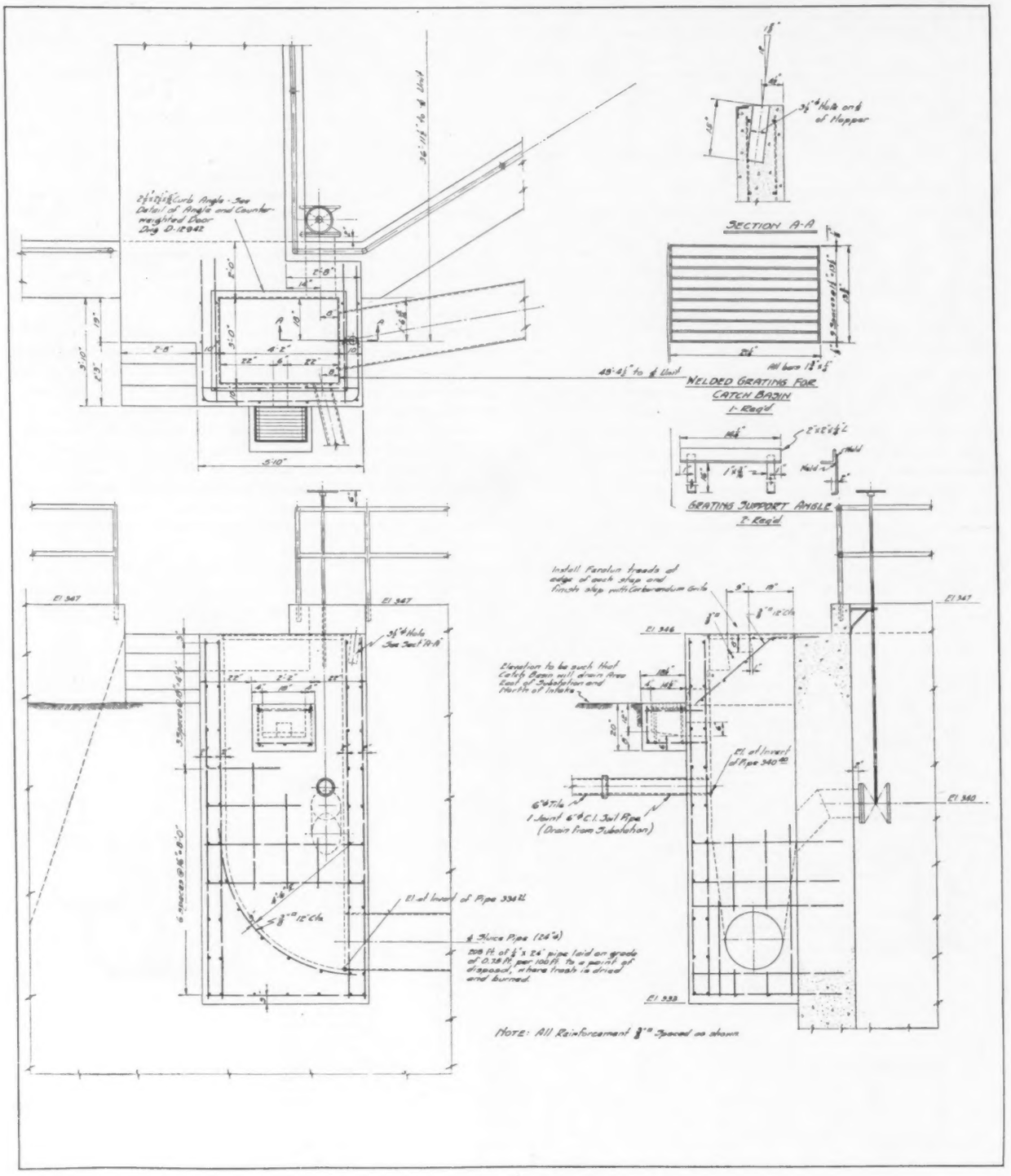



*Fig. 8. Big Creek No. 3 draft tube and tail race.*

others of different grade and grit until one of the proper characteristic is finally discovered. Usually bronze collector rings give a better performance than cast iron. When the surface of collector rings has become so grooved that it is difficult to fit new brushes to them, then the surface of the collector ring is refinished by either a cutting tool or a grinding wheel, the operation taking place while the rotor is revolving. When a grinding wheel is used, the speed of rotation may be normal, but when the material is removed by a lathe cutting tool, the speed must be extremely slow. The only objection to the use of the stone is the danger that it may be used too freely by a thoughtless operator and thus wear away the collector ring at an excessive rate."

### Use of Mercury Gage at Gem Lake

Fig. No. 7 shows the details of mercury gage used at Gem Lake and other reservoirs of the Southern Sierras system.

Among the advantages claimed for this gage are the following:

(1) Greater accuracy than staff gages, particularly under ice and wind conditions.

(2) Lower cost of installation than where stilling wells are required for staff gages.

### Operating Experience With Draft Tube at Big Creek No. 3

The following is a brief account of the work done on the Big Creek No. 3 draft tubes in order to improve the operation of turbines.

This plant, which was built in 1922, contained three Francis type turbines rated at 35,000 hp. under 760-ft. effective head. The predicted flow for full rated capacity was 500 sec.-ft. The acceptance tests on these machines showed an efficiency of only 84 per cent and a maximum capacity of about 530 sec.-ft. At high flows there was a great deal of vibration and excessive pounding in the upper section of the draft tube. It was apparent that the high velocity head at the point of discharge from the runner, added to the static draft head, produced a total draft head which was excessive. Runners and gates of a new design were installed in the turbines and a concrete pad added in the location shown in the sketch, which had the effect of throttling the discharge in the draft tube, thereby reducing the total draft head. (See Fig. 8.) The new runner has increased the efficiency of the turbines to approximately 90 per cent and the choke in the draft tube has had the effect of practically eliminating the pounding and cracking in the upper draft tube section and has done away with the vibration at high flows.

In addition to the increased efficiency, the units now have a capacity of about 42,000 hp. each, corresponding to a flow of 600 sec.-ft. One of the new runners was put in service about a year before the draft tube choke was added. After a year's operation this runner was found to be very badly pitted. It is hoped that with the improved draft tube conditions now existing this pitting will be reduced in the future, although no conclusions on this can be reached until after another year's operation.

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## *Mechanical Reliability of Hydro-Electric Units**

*The subcommittee on mechanical reliability of hydro-electric units presents herewith the seventh annual report on the operation of generating units within the territory of the Pacific Coast Electrical Association. The same*

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* Report of subcommittee on mechanical reliability of hydro-electric units, hydraulic power committee, Engineering Section. E. F. Maryatt, chairman. P. H. Gilbert, F. R. Harp, B. N. Merritt, Harry Olsen, L. M. Perrin, R. R. Robertson, George M. Wills.

TABLE II—OPERATING RECORD
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ANALYSIS OF IDLE TIME | | | | | | | | |
| PLANT INDEX NUMBER | KILOWATT RATING OF EACH GENERATOR | YEAR | KILOWATT HOURS GENERATED | AVERAGE SERVICE TIME | AVERAGE IDLE TIME | TOTAL | AVERAGE TOTAL OUTAGE TIME (9)+(10) | AVERAGE OUTAGE TIME WHEN IN DEMAND | AVERAGE OUTAGE TIME WHEN NOT IN DEMAND | AVERAGE RESERVE TIME (6)−(8) | AVERAGE DEMAND TIME (5)+(9) | MAXIMUM POSSIBLE SERVICE TIME (5)+(11) | AVERAGE CAPACITY FACTOR (4) / [(2)×760] | AVERAGE OUTPUT FACTOR (4) / [(2)×(5)] | AVERAGE SERVICE DEMAND AVAILABILITY FACTOR (5) / (12) |
| 1 | 13,500 | 1930 | 50,437,300 | 72.76 | 27.24 | 100 | 0.08 | .01 | 0.07 | 27.16 | 72.77 | 99.92 | 0.426 | 0.536 | 1.000 |
| 2 | 16,000 | 1930 | 86,642,000 | 72.06 | 27.94 | 100 | .046 | .023 | 0.023 | 27.90 | 72.08 | 99.96 | 0.618 | 0.858 | 1.000 |
| 3 | 10,000 | 1930 | 21,327,000 | 84.3 | 15.7 | 100 | 15.7 | 0. | 15.7 | 0. | 84.30 | 84.3 | 0.243 | 0.289 | 1.000 |
| 4 | 10,000 | 1930 | 35,351,000 | 86.7 | 13.3 | 100 | 13.3 | 0. | 13.3 | 0. | 86.70 | 86.7 | 0.404 | 0.465 | 1.000 |
| 5 | 31,500 | 1930 | 130,378,000 | 61.3 | 38.7 | 100 | 10.43 | 0. | 10.43 | 28.25 | 61.30 | 89.55 | 0.473 | 0.771 | 1.000 |
| 6 | 24,300 | 1930 | 116,371,333 | 79.37 | 20.63 | 100 | 1.30 | 0. | 1.30 | 19.264 | 79.372 | 98.634 | 0.546 | 0.689 | 1.000 |
| 7 | 11,360 | 1930 | 64,609,333 | 97.76 | 2.24 | 100 | 1.717 | .0266 | 1.69 | .52 | 97.78 | 98.28 | 0.649 | 0.664 | 0.999 |
| 8 | 8,480 | 1930 | 41,398,000 | 97.50 | 2.50 | 100 | 2.24 | 2.24 | 0. | .239 | 99.75 | 97.621 | 0.584 | 0.599 | 0.975 |
| 9 | 25,000 | 1930 | 159,361,067 | 68.70 | 31.30 | 100 | 11.09 | .09 | 11.00 | 20.21 | 68.79 | 88.91 | .723 | .922 | .999 |
| 10A | 22,500 | 1930 | 44,997,264 | 26.79 | 73.21 | 100 | 3.81 | .01 | 3.80 | 69.40 | 26.80 | 96.19 | .254 | .947 | .9998 |
| 10B | 31,500 | 1930 | 142,744,464 | 73.32 | 26.68 | 100 | .350 | .005 | .345 | 26.33 | 73.325 | 99.65 | .517 | .706 | 1.000 |
| 11 | 15,750 | 1930 | 71,000,000 | 67.71 | 32.29 | 100 | 9.13 | .01 | 9.12 | 23.16 | 67.72 | 90.87 | 0.515 | 0.760 | .9998 |
| 12A | 10,000 | 1930 | 54,824,750 | 99.4 | 0.6 | 100 | .354 | 0. | .354 | .247 | 99.5 | 99.65 | .968 | .974 | 1.000 |
| 12B | 10,000 | 1930 | 75,661,000 | 92.2 | 7.8 | 100 | 3.11 | .822 | 2.28 | 4.69 | 93.0 | 96.89 | .864 | .937 | .991 |
| 13 | 12,150 | 1930 | 34,947,500 | 52.61 | 47.4 | 100 | 0.285 | 0. | 0.285 | 47.10 | 52.61 | 99.70 | 0.328 | 0.624 | 1.000 |
| 14 | 14,000 | 1930 | 40,246,000 | 55.9 | 44.1 | 100 | | | | 44.1 | 55.9 | 100. | 0.328 | 0.587 | 1.000 |
| 15 | 6,400 | 1930 | 36,166,900 | 99.1 | .9 | 100 | .902 | 0. | .902 | 0. | 99.10 | 99.1 | .645 | .651 | 1.000 |
| 21 | 10,000 | 1930 | 38,669,900 | 72.88 | 27.12 | 100 | 0.09 | 0.01 | 0.08 | 27.03 | 72.89 | 99.91 | 0.441 | 0.606 | 1.000 |
| 22 | 12,000 | 1930 | 24,492,600 | 48.6 | 51.4 | 100 | 51.36 | 0. | 51.36 | 0. | 48.64 | 48.6 | .233 | .479 | 1.000 |
| 23 | 5,000 | 1930 | 13,089,000 | 99.6 | 0.4 | 100 | .434 | .434 | 0. | 0. | 100.034 | 99.6 | .299 | .300 | .996 |
| 31 | 20,000 | 1930 | 119,198,133 | 95.5 | 4.5 | 100 | 3.39 | 0. | 3.39 | 1.095 | 95.5 | 96.595 | .680 | .712 | 1.000 |
| 32 | 20,000 | 1930 | 113,277,950 | 87.4 | 12.6 | 100 | 2.59 | 0. | 2.59 | 10.01 | 87.4 | 97.38 | .647 | .740 | 1.000 |
| 33 | 6,000 | 1930 | 37,982,000 | 79.3 | 20.7 | 100 | 7.5 | 0. | 7.5 | 13.24 | 79.26 | 92.54 | .723 | .912 | 1.000 |
| 34 | 10,000 | 1930 | 40,596,650 | 96.6 | 3.4 | 100 | .39 | 0. | .39 | 2.98 | 96.63 | 99.58 | .463 | .480 | 1.000 |
| 35A | 12,000 | 1930 | 68,960,700 | 94.1 | 5.9 | 100 | 0.16 | 0. | 0.16 | 5.70 | 94.14 | 99.81 | .656 | .697 | 1.000 |
| 35B | 12,000 | 1930 | 75,705,600 | 95.3 | 4.7 | 100 | 0.14 | 0. | 0.14 | 4.58 | 95.28 | 99.88 | .720 | .756 | 1.000 |
| 35C | 12,000 | 1930 | 69,335,400 | 89.6 | 10.4 | 100 | 4.39 | 0. | 4.39 | 5.99 | 89.63 | 95.59 | .659 | .736 | 1.000 |
| 36A | 14,000 | 1930 | 77,694,000 | 83.75 | 16.25 | 100 | 5.84 | 0.14 | 5.70 | 10.41 | 83.89 | 94.16 | .634 | .756 | .998 |
| 36B | 15,750 | 1930 | 66,579,000 | 75.94 | 24.06 | 100 | 2.59 | 0. | 2.55 | 21.51 | 75.94 | 97.45 | .482 | .635 | 1.000 |
| 36C | 26,000 | 1930 | 122,773,000 | 78.84 | 21.16 | 100 | 14.43 | .99 | 14.44 | 5.73 | 79.83 | 84.57 | .561 | .711 | .988 |
| 37A | 14,000 | 1930 | 81,464,940 | 88.99 | 11.01 | 100 | 8.97 | 0. | 8.97 | 2.04 | 89.99 | 91.03 | .664 | .746 | 1.000 |
| 37B | 15,750 | 1930 | 67,309,020 | 75.44 | 24.56 | 100 | 7.61 | 0. | 7.61 | 16.95 | 75.44 | 92.39 | .487 | .647 | 1.000 |
| 37C | 40,000 | 1930 | 102,323,400 | 45.69 | 54.31 | 100 | 11.89 | 0. | 11.89 | 42.42 | 45.69 | 88.11 | .292 | .639 | 1.000 |
| 37D | 40,000 | 1930 | 88,058,400 | 35.79 | 64.21 | 100 | 4.28 | 0. | 4.28 | 59.93 | 35.79 | 95.72 | .251 | .702 | 1.000 |
| 38 | 5,000 | 1930 | 32,926,312 | 76.88 | 23.12 | 100 | 2.67 | .02 | 2.65 | 20.45 | 76.90 | 97.33 | .751 | .978 | .9997 |
| 39 | 10,000 | 1930 | 21,595,000 | 93.5 | 6.5 | 100 | 6.53 | 6.53 | 0. | 0. | 100. | 93.5 | .247 | .264 | .935 |
| 40 | 31,000 | 1930 | 112,721,000 | 95.3 | 4.7 | 100 | 3.11 | 3.11 | 0. | 1.64 | 98.36 | 96.49 | .415 | 0.436 | .968 |
| 41A | 10,000 | 1930 | 16,489,000 | 72.9 | 27.1 | 100 | 5.5 | 0.8 | 4.7 | 21.6 | 73.7 | 94.50 | .188 | .258 | .989 |
| 41B | 20,000 | 1930 | 80,007,800 | 79.3 | 20.7 | 100 | | | | 20.7 | 79.3 | 100.0 | .457 | .576 | 1.000 |
| 42 | 17,500 | 1930 | 120,974,188 | 89.26 | 10.74 | 100 | 0.99 | 0. | 0.99 | 9.75 | 89.26 | 99.01 | .789 | .884 | 1.000 |
| Average | 16,236 | | 70,742,298 | 78.45 | 21.55 | 100 | 5.52 | .38 | 5.11 | 16.43 | 73.39 | 94.49 | .521 | .667 | .996 |

TABLE I — HYDRO-ELECTRIC PLANT DATA
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

| INDEX NUMBER | KIND OF OPERATION | UNITS COVERED | RATED H.P. | YEAR | STATIC HEAD | NUMBER RUNNERS | R.P.M. | SETTING | GENERATOR KV-A. | GENERATOR P.F. | PRESSURE CONTROL | SHUT OFF VALVE TYPE | SHUT OFF VALVE SIZE | SHUT OFF VALVE CONTROL | GOVERNOR OIL SYSTEM | GOVERNOR DRIVE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VERTICAL TURBINE INSTALLATIONS** | | | | | | | | | | | | | | | | |
| 1 | Daily Peak | 2 | 20,000 | 1925 | 157 | 1 | 171.4 | Plate Steel Spiral | 15,000 | 0.90 | Surge Chamber | Butterfly | 140 | Motor & Hand | Individual | Belt |
| 2 | Run of River | 2 | 23,400 | 1928 | 607 | 1 | 514. | Cast Steel Spiral | 20,000 | 0.80 | Surge Chamber & Relief Valve | Butterfly | 72 | Motor & Hand | Individual | Belt |
| 3 | Daily Peak | 1 | 15,000 | 1921 | 216.8 | 1 | 225. | Cast Iron Spiral | 12,500 | 0.80 | Pressure Regulator | Butterfly | 90 | Motor | Individual | Belt |
| 4 | Base Load | 1 | 15,000 | 1921 | 197.9 | 1 | 225. | Cast Iron Spiral | 12,500 | 0.80 | Flume Spillway | Gates at Dam | | Motor | Individual | Belt |
| 5 | Run of River | 2 | 40,000 | 1922 | 454. | 1 | 257. | Cast Steel Spiral | 35,000 | 0.90 | Pressure Reg.& Surge Chamber | Butterfly | 108 | Motor | Central | D.C. |
| 6 | Daily Peak | 3 | 33,000 | 1925 | 315. | 1 | 225. | Cast Steel Spiral | 27,000 | 0.90 | Pressure Reg.& Surge Chamber | Butterfly | 108 | Motor | Individual | Gear |
| 7 | R. of R. & D.P. | 3 | 15,000 | 1920 | 350. | 1 | 360. | Cast Steel Spiral | 14,200 | 0.80 | Pressure Reg.& Surge Chamber | Butterfly | 84 | Motor | Individual | D.C. |
| 8 | Run of River | 1 | 12,000 | 1921 | 272. | 1 | 257. | Plate Steel Spiral | 10,600 | 0.80 | Pressure Reg.& Surge Chamber | Butterfly | 90 | Motor | Individual | D.C. |
| 9 | R. of R. & D.P. | 3 | 35,000 | 1923 | 818. | 1 | 428 | Cast Steel Spiral | 28,000 | 0.894 | Pressure Reg.& Surge Chamber | Plunger | 54 | Hyd., Hand & Motor | Central | Belt |
| 10A | Daily Peak | 1 | 30,000 | 1921 | 715. | 1 | 428. | Cast Steel Spiral | 25,000 | 0.90 | Pressure Reg.& Surge Chamber | Plunger | 72 | Hyd., Hand & Motor | Central | Belt |
| 10B | Daily Peak | 1 | 44,000 | 1929 | 715. | 1 | 375. | Cast Steel Spiral | 35,000 | 0.90 | Pressure Reg.& Surge Chamber | Butterfly | 84"x72" | Motor & Hand | Central | Gear |
| 11 | Run of River | 2 | 25,000 | 1921 | 820. | 1 | 500/600 | Cast Steel Spiral | 17,500 | 0.90 | Pressure Reg. | Plunger | 60 | Hyd., Hand & Motor | Central | Belt |
| 12A | Base Load | 4 | 16,500 | 1909 | 460. | 1 | 400. | Cast Steel Spiral | 10,000 | 1.00 | Pressure Reg.& Surge Pipe | Gate | 60 | Motor | Central | Belt |
| 12B | Base Load | 2 | 18,500 | 1914-16 | 460. | 1 | 400. | Cast Steel Spiral | 12,500 | 0.80 | Pressure Reg.& Surge Pipe | Butterfly | 72 | Hydraulic | Central | Belt |
| 13 | Seasonal Peak | 2 | 17,690 | 1927 | 225. | 1 | 277. | Riveted Steel Spiral | 13,500 | 0.90 | Pressure Regulator | Butterfly | 102 | Motor | Individual | Gear |
| 14 | Daily Peak | 2 | 20,900 | 1920 | 535. | 1 | 428. | Cast Iron Spiral | 17,500 | 0.80 | Pressure Reg.& Surge Chamber | Johnson | 72 | Hydraulic | Central | Belt |
| 15 | Base Load | 1 | 10,500 | 1928 | 197. | 1 | 257 | Cast Steel Spiral | 8,000 | 0.80 | Relief Valve | Butterfly | 72 | Motor | Individual | Gear |
| **HORIZONTAL TURBINE INSTALLATIONS** | | | | | | | | | | | | | | | | |
| 21 | Daily Peak | 2 | 18,600 | 1918-22 | 125 | 2 | 200 | Plate Steel Spiral | 12,500 | 0.80 | None | Gates at Intake | 52457 | Motor & Hand | Individual | Belt |
| 22 | Daily Peak | 1 | 20,000 | 1917 | 519 | 1 | 360 | Cast Steel Spiral | 15,000 | 0.80 | Pressure Regulator | Butterfly | 66 | Motor | Individual | Belt |
| 23 | Run of River | 1 | 7,500 | 1924 | 245.4 | 1 | 400 | Cast Steel Spiral | 6,250 | 1.00 | Relief Valve | Gate | | Hydraulic | Individual | Belt |
| **IMPULSE WATER-WHEEL INSTALLATIONS** | | | | | | | | | | | | | | | | |
| 31 | Base Load | 3 | 30,000 | 1921-24 | 1108 | 2 | 171.4 | | 22,223 | 0.90 | Pressure Reg.& Surge Chamber | Gate | 42 | Hydraulic | Central | Motor |
| 32 | Base Load & D.P. | 2 | 35,000 | 1927 | 2563 | 2 | 450 | | 25,000 | 0.80 | Surge Chamber & By Pass Needle | Gate | 26 | Hydraulic & Motor | Central | Belt |
| 33 | Base Load | 1 | 9,500 | 1921 | 1865 | 1 | 514 | | 7,500 | 0.80 | Jet Deflector | Gate | 24 | Motor | Individual | Belt |
| 34 | Daily & Seasonal | 2 | 14,000 | 1923 | 1750 | 1 | 300 | | 12,500 | 0.80 | Pressure Reg.& Surge Chamber | Gate | 28 | Hydraulic | Individual | Belt |
| 35A | Daily Peak | 2 | 18,000 | 1913 | 1375 | 2 | 360 | | 12,500 | 0.96 | Deflecting Nozzles | Gate | 36 | Water Motor | Central | Belt |
| 35B | Daily Peak | 1 | 18,000 | 1922 | 1375 | 2 | 360 | | 15,000 | 0.80 | Deflecting Nozzles | Gate | 36 | Water Motor | Central | Belt |
| 35C | Daily Peak | 1 | 18,000 | 1928 | 1375 | 1 | 257 | | 15,000 | 0.80 | By Pass Needle | Gate | 36 | Water Motor | Central | Gear |
| 36A | Daily Peak | 2 | 20,000 | 1913 | 2080 | 2 | 375 | | 17,500 | 0.80 | Relief Valve & By Pass Needle | Gate | 24 | Hydraulic Hand | Central | Belt |
| 36B | Daily Peak | 1 | 22,500 | 1923 | 2080 | 2 | 375 | | 17,500 | 0.90 | Relief Valve & By Pass Needle | Johnson | 24 | Hydraulic-Hand | Central | Belt |
| 36C | Daily Peak | 1 | 35,000 | 1925 | 2080 | 2 | 300 | | 28,000 | 0.894 | Relief Valve & By Pass Needle | Plunger | 30 | Hydraulic & Motor | Central | Belt |
| 37A | Daily Peak | 2 | 20,000 | 1913 | 1855 | 2 | 375 | | 17,500 | 0.80 | Relief Valve & By Pass Needle | Gate | 24 | Hydraulic - Hand | Central | Belt |
| 37B | Daily Peak | 2 | 22,500 | 1923-25 | 1855 | 2 | 375 | | 17,500 | 0.90 | Relief Valve & By Pass Needle | Plunger | 24 | Hydraulic - Motor-Hand | Central | Belt |
| 37C | Daily Peak | 1 | 56,000 | 1928 | 2418 | 2 | 250 | | 45,000 | 0.89 | Surge Chamber & Jet Deflector | Gate | 34 | Hydraulic, Motor-Hand | Central | Belt |
| 37D | Daily Peak | 1 | 56,000 | 1928 | 2418 | 2 | 250 | | 45,000 | 0.89 | Surge Chamber & Jet Deflector | Gate | 34 | Hydraulic, Motor-Hand | Central | Gear |
| 38 | Run of River | 4 | 10,750 | 1907 | 880 | 2 | 250 | | 5,000 | 0.80 | Deflecting Nozzle | Gate | 28 | Hand & Motor | Individual | Chain |
| 39 | Daily Peak | 1 | 14,000 | 1924 | 1673 | 1 | 360 | | 12,500 | 1.00 | Jet Deflector | Gate | | Water Motor | Individual | Belt |
| 40 | Daily Peak | 1 | 40,000 | 1927 | 2381 | 2 | 360 | | 11,000 | 0.94 | Pressure Reg.& Surge Chamber | Gate | 32 | Hydraulic | Central | Belt |
| 41A | Daily Peak | 1 | 16,000 | 1923 | 930 | 2 | 200 | | 12,500 | 0.80 | Surge Chamber & By Pass Needle | Needle Valve | 57 | Hydraulic | Central | Belt |
| 41B | Daily Peak | 1 | 32,200 | 1928 | 930 | 2 | 143 | | 25,000 | 0.80 | Surge Chamber & Jet Deflector | Needle Valve | 57 | Hydraulic | Central | Belt |
| 42 | Base Load & D.P. | 4 | 25,000 | 1925 | 1315 | 2 | 257 | | 20,000 | 0.875 | Surge Chamber & By Pass Needle | Gate | 36 | Hydraulic | Individual | Belt |

TABLE III—OPERATING RECORD
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, E.C.E.A.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PLANT INDEX NUMBER | KILOWATT RATING OF EACH GENERATOR | YEAR | KILOWATT HOURS GENERATED | AVERAGE SERVICE TIME | AVERAGE IDLE TIME | TOTAL | ANALYSIS OF IDLE TIME | | | | | MAXIMUM POSSIBLE SERVICE TIME | AVERAGE CAPACITY FACTOR | AVERAGE OUTPUT FACTOR | AVERAGE SERVICE DEMAND AVAILABILITY FACTOR |
| | | | | | | | AVERAGE TOTAL OUTAGE TIME | AVERAGE OUTAGE TIME WHEN IN DEMAND | AVERAGE OUTAGE TIME WHEN NOT IN DEMAND | AVERAGE RESERVE TIME | AVERAGE DEMAND TIME | | (4) / (2)×8760 | (4) / (2)×(5) | (5) / (12) |
| | | | | | | | (9)+(10) | | | (6)−(8) | (5)+(9) | (5)+(11) | | | |
| 1 | 13,500 | 5 Yr. Av. | 60,570,970 | 74.68 | 25.32 | 100 | 5.18 | 4.23 | .95 | 20.13 | 78.92 | 94.82 | .516 | .688 | .948 |
| | | 1930 | 59,437,300 | 72.76 | 27.24 | 100 | 0.08 | .01 | 0.07 | 27.16 | 72.77 | 99.92 | 0.426 | 0.536 | 1.000 |
| | | 6 Yr. Av. | 58,882,025 | 74.36 | 25.64 | 100 | 4.50 | 3.63 | .80 | 21.30 | 77.79 | 95.29 | .501 | .631 | .966 |
| | | 2 Yr. Av. | 77,127,250 | 87.40 | 12.6 | 100 | .31 | .18 | .12 | 12.28 | 87.59 | 99.69 | .585 | .573 | .998 |
| 2 | 16,000 | 1930 | 86,642,000 | 72.06 | 27.94 | 100 | .046 | .023 | 0.023 | 27.90 | 72.08 | 99.96 | 0.618 | 0.858 | 1.000 |
| | | 3 Yr. Av. | 76,093,170 | 82.29 | 17.71 | 100 | .222 | .131 | .091 | 17.49 | 82.42 | 99.78 | .542 | .659 | .998 |
| | | 6 Yr. Av. | 26,512,999 | 98.01 | 1.99 | 100 | 1.73 | .27 | 1.46 | .26 | 98.28 | 98.27 | .30 | .31 | .998 |
| 3 | 10,000 | 1930 | 21,327,000 | 84.3 | 15.7 | 100 | 15.7 | 0. | 15.7 | 0. | 84.30 | 84.3 | 0.243 | 0.289 | 1.000 |
| | | 7 Yr. Av. | 25,772,143 | 96.05 | 3.95 | 100 | 3.72 | .23 | 3.49 | .22 | 96.28 | 96.27 | .292 | .305 | .998 |
| | | 6 Yr. Av. | 44,506,834 | 97.08 | 2.92 | 100 | 1.94 | .13 | 1.81 | .98 | 97.21 | 99.06 | .508 | .523 | .999 |
| 4 | 10,000 | 1930 | 35,351,000 | 86.7 | 13.3 | 100 | 13.3 | 0. | 13.3 | 0. | 86.70 | 86.7 | 0.404 | 0.465 | 1.000 |
| | | 7 Yr. Av. | 43,128,860 | 95.69 | 4.31 | 100 | 1.561 | .111 | 1.450 | .837 | 95.71 | 96.44 | .492 | .515 | .999 |
| | | 6 Yr. Av. | 141,869,182 | 84.06 | 15.94 | 100 | .28 | | .28 | 15.66 | 84.06 | 99.72 | .514 | .507 | 1.000 |
| 5 | 31,500 | 1930 | 130,378,000 | 61.3 | 38.7 | 100 | 10.43 | 0. | 10.43 | 28.25 | 61.30 | 89.56 | 0.471 | 0.771 | 1.000 |
| | | 5 Yr. Av. | 139,579,900 | 61.51 | 36.49 | 100 | 2.31 | 0. | 2.31 | 34.17 | 63.51 | 97.68 | .506 | .799 | 1.000 |
| | | 4 Yr. Av. | 122,145,000 | 78.42 | 21.58 | 100 | 1.33 | 0. | 1.33 | 18.26 | 78.41 | 96.67 | .573 | .732 | 1.000 |
| 6 | 24,300 | 1930 | 116,373,333 | 79.37 | 20.63 | 100 | 1.30 | 0. | 1.30 | 19.264 | 79.372 | 98.634 | 0.546 | 0.689 | 1.000 |
| | | 5 Yr. Av. | 120,990,666 | 78.61 | 21.39 | 100 | 2.92 | 0. | 2.92 | 18.457 | 78.606 | 97.063 | .568 | .724 | 1.000 |
| | | 6 Yr. Av. | 60,731,790 | 92.78 | 7.22 | 100 | 2.42 | .15 | 2.26 | 4.81 | 92.93 | 97.58 | .609 | .651 | .993 |
| 7 | 11,360 | 1930 | 64,609,333 | 97.76 | 2.24 | 100 | 1.717 | .0266 | 1.69 | .52 | 97.78 | 98.28 | 0.649 | 0.664 | 0.999 |
| | | 7 Yr. Av. | 61,285,723 | 93.49 | 6.51 | 100 | 2.32 | 1.39 | 2.18 | 4.19 | 93.62 | 97.68 | .615 | .653 | .998 |
| | | 6 Yr. Av. | 44,262,500 | 97.72 | 2.28 | 100 | 1.88 | 1.87 | .00 | .42 | 99.58 | 98.13 | .596 | .602 | .981 |
| 8 | 8,480 | 1930 | 43,398,000 | 97.50 | 2.50 | 100 | 2.24 | 2.24 | 0. | .239 | 99.75 | 97.621 | 0.584 | 0.599 | 0.975 |
| | | 7 Yr. Av. | 44,139,000 | 97.48 | 2.51 | 100 | 1.92 | 1.92 | .003 | .59 | 99.60 | 97.89 | .598 | .60 | .98 |
| | | 6 Yr. Av. | 135,802,200 | 66.69 | 33.31 | 100 | 9.95 | 8.85 | 8.85 | 24.32 | 67.59 | 91.82 | .602 | .913 | .987 |
| 9 | 25,000 | 1930 | 158,361,067 | 68.70 | 31.30 | 100 | 11.09 | .09 | 11.00 | 20.21 | 68.79 | 88.91 | .723 | .922 | .999 |
| | | 6 Yr. Av. | 139,228,678 | 67.03 | 32.97 | 100 | 9.33 | .76 | 8.57 | 23.65 | 67.79 | 90.66 | .637 | .950 | .985 |
| | | 6 Yr. Av. | 118,100,250 | 72.30 | 27.70 | 100 | 4.92 | 2.97 | 1.95 | 22.78 | 75.27 | 95.08 | .599 | .764 | .951 |
| 10A | 22,500 | 1930 | 44,997,264 | 26.79 | 73.21 | 100 | 3.81 | .01 | 3.80 | 69.40 | 26.80 | 96.19 | .254 | .947 | .9998 |
| | | 7 Yr. Av. | 103,371,275 | 65.80 | 34.19 | 100 | 4.76 | 2.55 | 2.22 | 29.43 | 68.35 | 95.24 | .549 | .835 | .9607 |
| | | 1929 | 106,872,681 | 83.43 | 16.57 | 100 | 4.14 | 0. | 4.14 | 12.43 | 83.43 | 95.86 | .629 | .814 | 1.000 |
| 10B | 31,500 | 1930 | 142,744,464 | 72.32 | 26.68 | 100 | .350 | .005 | .345 | 26.33 | 73.325 | 99.65 | .517 | .706 | 1.000 |
| | | 2 Yr. Av. | 124,808,573 | 78.37 | 21.62 | 100 | 2.24 | .002 | 2.242 | 19.38 | 78.377 | 97.75 | .598 | .760 | 1.000 |
| | | 6 Yr. Av. | 73,065,460 | 69.25 | 30.75 | 100 | 5.42 | .54 | 4.88 | 27.05 | 69.12 | 94.58 | .535 | .786 | .992 |
| 11 | 15,750 | 1930 | 71,000,000 | 67.71 | 32.29 | 100 | 9.13 | .01 | 9.12 | 23.16 | 67.72 | 90.87 | 0.515 | 0.760 | .9998 |
| | | 7 Yr. Av. | 73,458,679 | 67.59 | 32.40 | 100 | 5.95 | .47 | 5.48 | 26.45 | 68.06 | 94.05 | .532 | .782 | .9628 |
| | | 4 Yr. Av. | 70,958,933 | 93.04 | 6.96 | 100 | 4.00 | .26 | 3.74 | 2.96 | 93.30 | 96.00 | .809 | .869 | .998 |
| 12A | 10,000 | 1930 | 84,824,750 | 99.4 | 0.6 | 100 | .354 | 0. | .354 | .247 | 99.5 | 99.65 | .968 | .974 | 1.000 |
| | | 5 Yr. Av. | 73,732,100 | 94.31 | 5.68 | 100 | 3.271 | .21 | 3.063 | 2.415 | 94.52 | 96.73 | .841 | .889 | .998 |
| | | 4 Yr. Av. | 66,282,125 | 95.50 | 4.50 | 100 | .69 | .03 | .62 | 3.80 | 95.58 | 99.30 | .756 | .792 | .999 |
| 12B | 10,000 | 1930 | 75,661,000 | 92.2 | 7.8 | 100 | 3.11 | .822 | 2.28 | 4.69 | 93.0 | 96.89 | .864 | .937 | .991 |
| | | 5 Yr. Av. | 68,157,900 | 94.84 | 4.14 | 100 | 1.17 | .224 | .95 | 2.97 | 95.07 | 98.81 | .777 | .821 | .998 |
| | | 3 Yr. Av. | 31,924,311 | 43.63 | 46.37 | 100 | 9.30 | 0. | 9.30 | 37.07 | 53.63 | 90.69 | .376 | .292 | 1.000 |
| 13 | 12,150 | 1930 | 34,947,500 | 52.61 | 47.4 | 100 | 0.289 | 0. | 0.289 | 47.10 | 52.61 | 99.70 | 0.328 | 0.624 | 1.000 |
| | | 4 Yr. Av. | 34,033,135 | 51.37 | 48.63 | 100 | 7.049 | 0. | 7.049 | 39.57 | 53.37 | 92.94 | .319 | .599 | 1.000 |
| | | 2 Yr. Av. | 37,275,500 | 56.72 | 43.28 | 100 | 1.66 | .24 | 1.42 | 41.61 | 56.96 | 98.34 | .304 | .532 | .995 |
| 14 | 14,000 | 1930 | 40,246,000 | 55.9 | 44.1 | 100 | | | | 44.1 | 55.9 | 100. | 0.329 | 0.587 | 1.000 |
| | | 3 Yr. Av. | 38,265,666 | 56.45 | 43.55 | 100 | 1.11 | .16 | .94 | 42.44 | 56.61 | 98.89 | .312 | .551 | .997 |
| | | 1929 | 28,097,000 | 72.24 | 27.76 | 100 | 7.98 | 0. | 7.98 | 19.78 | 72.24 | 92.02 | .358 | .496 | 1.000 |
| 15 | 6,400 | 1930 | 36,166,900 | 99.1 | .9 | 100 | .902 | 0. | .902 | 0. | 99.10 | 99.1 | .645 | .651 | 1.000 |
| | | 2 Yr. Av. | 28,131,950 | 85.69 | 14.31 | 200 | 4.441 | 0. | 4.441 | 9.89 | 85.67 | 95.56 | .501 | .585 | 1.000 |
| | | 5 Yr. Av. | 24,389,550 | 79.04 | 20.95 | 100 | 3.02 | 2.47 | .61 | 17.08 | 81.59 | 97.01 | .599 | .732 | .970 |
| 21 | 10,000 | 1930 | 38,669,900 | 72.88 | 27.12 | 100 | 0.08 | 0.01 | 0.08 | 27.03 | 72.89 | 99.91 | 0.441 | 0.606 | 1.000 |
| | | 6 Yr. Av. | 50,102,942 | 77.99 | 22.00 | 100 | 2.53 | 2.06 | .44 | 19.56 | 80.05 | 97.50 | .571 | .732 | .974 |
| | | 6 Yr. Av. | 33,184,500 | 83.33 | 16.68 | 100 | 8.91 | .68 | 8.24 | 7.76 | 84.01 | 91.09 | .315 | .377 | .992 |
| 22 | 12,000 | 1930 | 24,492,600 | 48.6 | 51.4 | 100 | 51.36 | 0. | 51.36 | 0. | 48.64 | 48.6 | .233 | .479 | 1.000 |
| | | 7 Yr. Av. | 31,942,800 | 78.36 | 21.63 | 100 | 14.97 | .586 | 14.39 | 6.65 | 78.96 | 85.02 | .304 | .358 | .993 |
| | | 4 Yr. Av. | 15,473,250 | 97.78 | 2.22 | 100 | 1.66 | 1.66 | 0. | .56 | 99.43 | 98.37 | .328 | .336 | .983 |
| 23 | 5,000 | 1930 | 13,089,000 | 99.6 | 0.4 | 100 | .434 | .434 | 0. | 0. | 100.034 | 99.6 | .299 | 30.0 | 99.6 |
| | | 5 Yr. Av. | 16,296,400 | 98.14 | 1.86 | 100 | 1.417 | 1.417 | 0. | .45 | 99.56 | 98.59 | .380 | .395 | .996 |
| | | 4 Yr. Av. | 116,335,600 | 91.85 | 8.15 | 100 | 2.30 | .21 | 2.09 | 5.84 | 92.07 | 97.69 | .664 | .716 | .999 |
| 31 | 20,000 | 1930 | 119,198,133 | 95.5 | 4.5 | 100 | 3.39 | 0. | 3.39 | 1.065 | 95.5 | 96.595 | .680 | .711 | 1.000 |
| | | 5 Yr. Av. | 116,910,511 | 92.58 | 7.42 | 100 | 2.52 | .17 | 2.35 | 4.885 | 92.75 | 97.473 | .667 | .721 | .998 |
| | | 2 Yr. Av. | 93,098,325 | 70.25 | 29.75 | 100 | 1.91 | | 1.91 | 27.85 | 70.24 | 98.10 | .534 | .756 | 1.000 |
| 32 | 20,000 | 1930 | 113,577,950 | 87.4 | 12.6 | 100 | 2.59 | 0. | 2.59 | 10.01 | 97.4 | 97.38 | .647 | .740 | 1.000 |
| | | 3 Yr. Av. | 100,425,200 | 75.97 | 24.03 | 100 | 2.14 | 0. | 2.14 | 21.89 | 75.97 | 97.86 | .571 | .751 | 1.000 |
| | | 6 Yr. Av. | 24,956,750 | 67.22 | 32.78 | 100 | 5.50 | .29 | 5.21 | 27.28 | 67.52 | 94.50 | .475 | .732 | .997 |
| 33 | 6,000 | 1930 | 37,582,000 | 79.3 | 20.7 | 100 | 7.5 | 0. | 7.5 | 13.24 | 79.26 | 92.54 | .723 | .912 | 1.000 |
| | | 7 Yr. Av. | 26,843,214 | 68.95 | 31.05 | 100 | 5.78 | .25 | 5.53 | 25.27 | 69.20 | 94.22 | .51 | .758 | .999 |
| | | 4 Yr. Av. | 37,921,571 | 83.53 | 16.47 | 100 | 5.04 | 1.47 | 3.57 | 11.44 | 85.00 | 94.96 | .448 | .530 | .983 |
| 34 | 10,000 | 1930 | 40,596,650 | 96.6 | 3.4 | 100 | .39 | 0. | .39 | 2.98 | 96.63 | 99.58 | .463 | .480 | 1.000 |
| | | 5 Yr. Av. | 33,456,597 | 86.13 | 13.86 | 100 | 1.81 | 1.17 | .631 | 9.96 | 87.11 | 98.02 | .438 | .502 | .992 |
| | | 4 Yr. Av. | 33,915,125 | 86.02 | 13.98 | 100 | 6.61 | .14 | 5.46 | 8.37 | 86.14 | 93.39 | .321 | .372 | .999 |
| 35A | 12,000 | 1930 | 49,960,700 | 94.1 | 5.9 | 100 | 0.16 | 0. | 0.16 | 5.70 | 94.14 | 99.81 | .456 | .497 | 1.000 |
| | | 5 Yr. Av. | 40,811,335 | 87.64 | 12.36 | 100 | 5.32 | .114 | 5.20 | 7.04 | 87.75 | 94.67 | .338 | .443 | .999 |
| | | 4 Yr. Av. | 34,169,100 | 84.61 | 15.39 | 100 | 7.33 | .14 | 7.13 | 8.06 | 84.75 | 92.67 | .326 | .385 | .999 |
| 35B | 12,000 | 1930 | 75,705,600 | 95.3 | 4.7 | 100 | 0.14 | 0 | 0.14 | 4.58 | 95.28 | 99.88 | .720 | .756 | 1.000 |
| | | 5 Yr. Av. | 43,476,400 | 86.75 | 13.25 | 100 | 5.89 | .114 | 5.77 | 7.36 | 86.86 | 94.11 | .403 | .445 | .999 |
| | | 2 Yr. Av. | 59,366,200 | 93.28 | 6.72 | 100 | 2.29 | 0. | 2.29 | 4.14 | 93.55 | 97.42 | .566 | .608 | 1.000 |
| 35C | 12,000 | 1930 | 62,335,400 | 89.6 | 10.4 | 100 | 4.39 | 0. | 4.39 | 5.98 | 89.63 | 95.59 | .659 | .736 | 1.000 |
| | | 3 Yr. Av. | 61,042,767 | 92.06 | 7.94 | 100 | 3.19 | 0. | 3.17 | 4.72 | 92.85 | 96.81 | .597 | .661 | .998 |
| | | 4 Yr. Av. | 79,270,450 | 80.59 | 19.41 | 100 | 2.74 | .01 | 2.73 | 16.77 | 80.32 | 96.94 | .643 | .796 | .999 |
| 36A | 14,000 | 1930 | 82,694,000 | 83.96 | 16.29 | 100 | 0.84 | 0.14 | 0.70 | 15.41 | 83.99 | 99.16 | .634 | .756 | 1.000 |
| | | 5 Yr. Av. | 79,715,166 | 81.16 | 18.84 | 100 | 4.10 | .0334 | 4.13 | 14.66 | 81.19 | 95.83 | .643 | .788 | .999 |
| | | 5 Yr. Av. | 81,238,267 | 81.28 | 18.72 | 100 | 2.70 | .01 | 2.69 | 16.10 | 81.29 | 97.30 | .503 | .734 | .999 |
| 36B | 15,750 | 1930 | 66,578,000 | 75.94 | 24.06 | 100 | 2.55 | 0. | 2.55 | 21.51 | 75.94 | 97.45 | .432 | .635 | 1.000 |
| | | 6 Yr. Av. | 80,456,555 | 80.39 | 19.61 | 100 | 2.78 | .005 | 2.67 | 16.93 | 80.39 | 97.32 | .583 | .725 | 1.000 |
| | | 5 Yr. Av. | 142,031,600 | 77.75 | 22.25 | 100 | 2.41 | .22 | 2.19 | 19.84 | 77.97 | 97.59 | .650 | .833 | .997 |
| 36C | 25,000 | 1930 | 122,778,000 | 78.84 | 21.16 | 100 | 15.43 | .99 | 14.44 | 5.73 | 79.83 | 84.57 | .561 | .711 | .988 |
| | | 6 Yr. Av. | 138,324,333 | 77.53 | 22.07 | 100 | 4.58 | .34 | 4.21 | 17.49 | 78.28 | 95.42 | .635 | .813 | .996 |
| | | 4 Yr. Av. | 85,030,240 | 86.30 | 13.70 | 100 | 2.34 | .30 | 2.04 | 10.36 | 86.60 | 96.66 | .750 | .866 | .996 |
| 37A | 14,000 | 1930 | 91,464,900 | 88.89 | 11.01 | 100 | 5.97 | 0. | 5.97 | 5.04 | 88.992 | 94.03 | .664 | .746 | 1.000 |
| | | 5 Yr. Av. | 86,797,179 | 86.54 | 13.46 | 100 | 4.46 | .24 | 4.22 | 9.70 | 87.08 | 95.54 | .707 | .810 | .997 |
| | | 5 Yr. Av. | 84,068,252 | 85.39 | 14.61 | 100 | 1.81 | .27 | 1.54 | 13.40 | 85.66 | 98.19 | .608 | .726 | .999 |
| 37B | 15,750 | 1930 | 67,309,020 | 75.24 | 24.76 | 100 | 7.61 | 0. | 7.61 | 16.95 | 75.44 | 92.39 | .487 | .647 | 1.000 |
| | | 6 Yr. Av. | 81,241,211 | 83.73 | 16.26 | 100 | 4.77 | .22 | 4.55 | 11.49 | 81.96 | 97.22 | .598 | .730 | .997 |
| | | 1929 | 97,779,400 | 41.32 | 58.68 | 100 | 17.16 | 0. | 17.16 | 41.52 | 41.32 | 82.84 | .251 | .606 | 1.000 |
| 37C | 40,000 | 1930 | 102,323,400 | 45.69 | 54.31 | 100 | 11.89 | 0. | 11.89 | 42.42 | 45.69 | 88.11 | .292 | .639 | 1.000 |
| | | 2 Yr. Av. | 95,051,400 | 43.60 | 56.40 | 100 | 14.52 | 0. | 14.52 | 41.87 | 43.60 | 85.47 | .281 | .622 | 1.000 |
| | | 1929 | 80,445,000 | 35.92 | 64.08 | 100 | 3.06 | 0. | 3.06 | 59.02 | 35.92 | 96.94 | .230 | .590 | 1.000 |
| 37D | 40,000 | 1930 | 88,008,400 | 35.29 | 64.71 | 100 | 4.28 | 0. | 4.28 | 59.93 | 35.29 | 95.72 | .251 | .702 | 1.000 |
| | | 2 Yr. Av. | 84,251,700 | 37.45 | 62.54 | 100 | 3.67 | 0. | 3.67 | 58.98 | 37.35 | 96.33 | .240 | .636 | 1.000 |
| | | 4 Yr. Av. | 20,639,621 | 81.47 | 18.53 | 100 | 2.29 | 1.75 | .54 | 16.24 | 81.22 | 97.71 | .588 | .740 | .990 |
| 38 | 5,000 | 1930 | 32,926,312 | 76.88 | 23.12 | 100 | 2.67 | .02 | 2.65 | 20.45 | 76.90 | 97.33 | .751 | .970 | .9997 |
| | | 5 Yr. Av. | 23,096,959 | 80.55 | 19.45 | 100 | 2.36 | 1.40 | .96 | 17.09 | 81.95 | 97.64 | .527 | .654 | .9937 |
| | | 4 Yr. Av. | 21,362,250 | 82.61 | 17.39 | 100 | .38 | .18 | .19 | 17.01 | 82.80 | 99.62 | .195 | .241 | .999 |
| 39 | 10,000 | 1930 | 21,595,000 | 93.5 | 6.5 | 100 | 6.53 | 6.53 | 0. | 0. | 100 | 93.5 | .247 | .264 | .935 |
| | | 5 Yr. Av. | 21,688,800 | 84.79 | 15.21 | 100 | 1.62 | 1.45 | .16 | 13.61 | 86.33 | 98.38 | .247 | .291 | .982 |
| | | 3 Yr. Av. | 113,888,332 | 79.43 | 20.57 | 100 | 5.74 | 3.92 | 1.83 | 14.84 | 85.33 | 94.27 | .415 | .523 | .980 |
| 40 | 31,500 | 1930 | 112,721,000 | 95.3 | 4.7 | 100 | 3.11 | 3.11 | 0. | 1.64 | 96.36 | 96.49 | .415 | 0.436 | .968 |
| | | 3 Yr. Av. | 113,671,600 | 83.94 | 16.6 | 100 | 5.08 | 1.71 | 1.29 | 11.51 | 87.05 | 94.92 | .415 | .498 | .954 |
| | | 2 Yr. Av. | 21,079,800 | 77.94 | 22.06 | 100 | | | | | | | .264 | .378 | |
| 41A | 10,000 | 1930 | 16,489,000 | 72.3 | 27.1 | 100 | 5.5 | 0.8 | 4.7 | 21.6 | 73.7 | 94.50 | .188 | .258 | .279 |
| | | 3 Yr. Av. | 20,882,870 | 72.26 | 27.74 | 100 | 1.87 | 0.27 | 1.6 | 25.87 | 72.53 | 98.13 | .233 | .329 | .967 |
| | | 1929 | 71,695,100 | 77.68 | 22.32 | 100 | | | | | | | .409 | .526 | |
| 41B | 20,000 | 1930 | 80,007,800 | 79.3 | 20.7 | 100 | | | | 20.7 | 79.3 | 100.0 | .457 | .576 | 1.000 |
| | | 2 Yr. Av. | 75,831,450 | 78.49 | 21.51 | 100 | | | | 21.51 | 78.49 | 100.0 | .433 | .551 | 1.000 |
| | | 1929 | 114,622,000 | 85.76 | 14.24 | 100 | 5.20 | 0. | 5.20 | 9.04 | 85.76 | 94.80 | .748 | .872 | 1.000 |
| 42 | 17,500 | 1930 | 120,974,188 | 90.26 | 10.74 | 100 | 0.99 | 0. | 0.99 | 9.75 | 90.26 | 99.01 | .779 | .863 | 1.000 |
| | | 2 Yr. Av. | 117,798,094 | 87.51 | 12.49 | 100 | 1.09 | 0. | 1.09 | 9.39 | 87.51 | 98.90 | .763 | .872 | 1.000 |

TABLE IV-A—ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

VERTICAL TURBINE INSTALLATIONS

| Plant Index Number | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | | 8 | | | 9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year / Item — Cause | 5Yr.Avg. | 1930 | 6Yr.Avg. | 2Yr.Avg. | 1930 | 3Yr.Avg. | 6Yr.Avg. | 1930 | 7Yr.Avg. | 6Yr.Avg. | 1930 | 7 Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 6Yr.Avg. | 1930 | 7Yr.Avg. | 6Yr.Avg. | 1930 | 7Yr.Avg. | 5Yr.Avg. | 1930 | 6Yr.Avg. |
| 13. GENERAL HYDRAULIC CAUSES: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Ice or Trash | | | | | | | | | | | | | | | | | | | 13.72 | 4.08[b] | 12.34 | | | | | | |
| (b) Floods | | | | 10.26 | | 6.84 | | | | | | | | | | | | | | | | | | | 15.00 | 15.40 | 15.07 |
| (c) Penstock or Canal | | | | | | | 4.00 | | 3.4 | | | | | | | 50.75 | | 40.60 | | | | | | | 4.00 | | 4.00 |
| (d) Headgates or Intake | | | | | | | | | | | | | | | | | | | 2.17 | | 1.86 | | 196.65 | 28.09 | 48.00 | | 40.00 |
| (e) Other General Hydraulic | 4.65 | | 3.87 | | | | | | | | | | 3.50 | | 2.8 | 112.75 | | 250.20 | | | | | | | | | |
| (f) TOTAL GENERAL HYDRAULIC: | 4.65 | | 3.87 | 10.26 | | 6.84 | 4.00 | | 3.4 | 30.17 | 264. | 64.30 | 3.50 | 0 | 2.8 | 163.50 | 0 | 290.80 | 15.89 | 4.08 | 14.20 | | 196.65 | 28.09 | 67.00 | 15.40 | 59.07 |
| 14. WATER WHEELS AND AUXILIARIES: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Runner | 418.17 | | 348.48 | | | | | | | .50 | | 0.43 | 16.25 | 1224. | 257.80 | | | | 150.00 | 123.5[c] | 146.22 | | | | 358.5[a] | 2850.4[a] | 773.82 |
| (b) Shut-off Valve | | | | | | | | | | | | | | | | 7.25 | 30. | 11.80 | | | | | | | 76.47 | 18.38 | 66.62 |
| (c) Turbine Gates or Needle Nozzle | .88 | | .74 | | | | | | | | | | | | | 6.00 | 3. | 5.40 | 1.42 | 1.17 | 1.38 | | | | 23.80 | 5.25 | 20.76 |
| (d) Guide Bearings or Main Bearings | 3.89 | | 3.24 | | | | 2.00 | 1. | 1.86 | 2.50 | | 2.14 | | | | 2.00 | | 1.60 | 150.67 | 98.25 | 142.82 | 6.83 | | 5.86 | 112.16 | | 114.45 |
| (e) Thrust Bearing | | | | | | | 11.50 | | 27.00 | 23.17 | | 19.86 | | | | | | | 46.50 | | 39.86 | 4.00 | | 3.43 | 7.00 | | 5.83 |
| (f) Governor and Governor System | 22.15 | 5.25 | 19.13 | 7.87 | 4.50 | 6.58 | 1.17 | | 1.00 | 1.50 | | 1.29 | 1.25 | | 1.0 | 4.50 | | 3.60 | 18.42 | | 15.78 | .91 | | .78 | 6.86 | 14.88 | 8.19 |
| (g) Pressure Regulator or Deflectors | | | | | | | | | | | | | | 50. | 10.0 | 203.50 | 298. | 222.40 | 12.43 | 6.97 | 11.64 | .66 | | .57 | .89 | | .67 |
| (h) Draft Tube | | | | | | | 1.83 | | 1.57 | | | | | 538. | 107.60 | | | | 2.00 | | 1.71 | 1.75 | | 1.42 | 10.82 | | 9.26 |
| (i) Lubrication System | .30 | | .25 | 2.45 | | 1.61 | | | | | | | 23.25 | 11. | 20.90 | 5.0 | 3. | 4.60 | 10.97 | | 9.40 | 1.00 | | .86 | 103.63 | | 36.37 |
| (j) Vibration | .88 | | .73 | | | | | | | | | | | | | | | | | | | | | | | | |
| (k) Seal Rings | 2.72 | | 2.24 | | | | | | | | | | | | | 150.0 | 1. | 120.20 | 12.25 | | 10.50 | 9.66 | | 8.28 | | | |
| (l) Inspection | 5.72 | 2.25 | 5.58 | 1.60 | 0.50 | 2.5[c] | 2.0 | | 1.71 | 1.50 | | 1.29 | 5.00 | | 4.0 | .75 | 6. | 1.00 | 2.93 | | 2.41 | .16 | | .14 | 29.48 | 3.63 | 25.34 |
| (m) General Overhauling and Replacement | 59.52 | | 49.66 | 8.85 | | 5.90 | | 1366.0 | 195.14 | | 896.[e] | 128.00 | | | | | | | 1.33 | | 1.11 | | | | 148.30 | | 123.58 |
| (n) Other Causes | | | | | | | | | | | | | | | | | | | 47.33 | | 40.57 | 132.66 | | 113.71 | 124.56 | | 103.80 |
| (o) TOTAL WATER WHEEL: | 514.76 | 7.50 | 430.22 | 22.53 | 5.0 | 16.09 | 18.50 | 1367.0 | 228.28 | 29.17 | 896 | 153.00 | 45.75 | 1823 | 401.20 | 379.0 | 341. | 371.40 | 456.15 | 227.94 | 421.51 | 159.65 | | 136.85 | 1027.57 | 2992.57 | 1139.40 |
| 15. GENERATOR AND APPURTENANCES: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Vibration | | | | | | | | | | | | | | | | | | | | | | | | | 16.40 | | 13.66 |
| (b) Lubrication or Oil Leakage | | | | | | | 77.00 | | 66.0 | 94.00 | | 80.57 | | | | 97.00 | | 77.60 | | 2.88 | .41 | | | | 130.84 | .47 | 109.11 |
| (c) Rotor or Field | | | | 4.04 | | 2.69 | | | | .19 | | .14 | | | | 15.75 | | 12.60 | 24.66 | | 21.14 | 1.08 | | .93 | 609.52 | 1.76 | 525.86 |
| (d) Armature Iron or Windings | | | | | | | | | | | | | | | | 18.00 | | 14.40 | | | | | | | 267.40 | | 222.83 |
| (e) Exciter and Rheostats | 2.59 | 6.5 | 3.25 | .43 | | .28 | 5.83 | 8.0 | 6.15 | .50 | | .43 | | 5.0 | 1.0 | 3.25 | | 2.60 | 1.81 | | 1.57 | | | | .80 | | .66 |
| (f) Ventilation System | | | | | | | | | | | | | | | | | | | 1.00 | | .86 | | | | .75 | 2.98 | 1.83 |
| (g) Cleaning | 1.60 | | 1.33 | | | | 14.17 | | 12.13 | 5.83 | | 5.00 | | | | | | | 65.45 | 261.32[c] | 87.00 | .17 | | .14 | 228.20 | | 233.83 |
| (h) Inspection | .80 | | .67 | 6.90 | 1.75 | 4.57 | 12.67 | | 10.86 | 6.00 | | 1.28 | | | | | | | | | | | | | 9.00 | | 2.50 |
| (i) Other Causes | 2.58 | | 2.15 | .65 | | .44 | .17 | | .14 | 5.00 | | 4.29 | .25 | | .20 | | | | 76.80 | | 60.68 | 3.58 | | 1.06 | 38.69 | | 10.21 |
| (j) TOTAL GENERATOR: | 7.57 | 6.50 | 7.40 | 11.10 | 1.75 | 7.97 | 109.84 | 8.0 | 95.28 | 110.50 | c. | 94.70 | .25 | 5.0 | 1.20 | 134.00 | 0 | 107.20 | 163.71 | 219.20 | 171.66 | 4.83 | | 1.13 | 1316.91 | 7.21 | 1101.10 |
| 16. TOTAL ALL CAUSES,- (13+14+15) | 526.99 | 14.0 | 441.49 | 43.88 | 6.95 | 31.50 | 152.33 | 1375.0 | 327.00 | 169.81 | 1165.00 | 312.00 | 49.50 | 1828. | 405.20 | 876.50 | 341. | 769.4 | 635.75 | 451.22 | 609.40 | 164.49 | 196.65 | 169.88 | 2331.28 | 2915.18 | 2428.57 |
| 17. NUMBER OF UNITS COVERED | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 3 |
| 18. AVERAGE OUTAGE HOURS PER UNIT | 263.49 | 7.0 | 220.74 | 21.99 | 3.47 | 15.75 | 152.33 | 1375.0 | 327.00 | 168.83 | 1165.00 | 312.00 | 24.75 | 914. | 202.60 | 292.17 | 113.67 | 256.46 | 211.92 | 150.41 | 203.13 | 164.49 | 196.65 | 169.88 | 777.1 | 971.73 | 809.53 |

a - New bronze sleeve on W.W.Shaft. New oil pan. Overhaul Governor Systems.
b - Removing ties from runner.
c - Patching runner.
d - Scraping lower guide bearing
e - Thorough cleaning.
f - Slide at intake
g - Reconstruction of turbines.

TABLE IV-B—ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

VERTICAL TURBINE INSTALLATIONS

| Plant Index Number | 10A | | | 10B | | | 11 | | | 12A | | | 12B | | | 13 | | | 14 | | | 15 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year / Item — Cause | 6Yr.Avg. | 1930 | 7Yr.Avg. | 1929 | 1930 | 2Yr.Avg. | 6Yr.Avg. | 1930 | 7Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 3Yr.Avg. | 1930 | 4Yr.Avg. | 2Yr.Avg. | 1930 | 3Yr.Avg. | 1929 | 1930 | 2Yr.Avg. |
| 13. GENERAL HYDRAULIC CAUSES: | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Ice or Trash | 5.0 | | 3.28 | | | | 2.59 | | 2.22 | | | | | | | | | | | | | | | |
| (b) Floods | | | 55.98 | | | | | | | | | | | | | | | | | | | | | |
| (c) Penstock or Canal | 65.31 | | | 9.0 | | 4.5 | 23.11 | | 19.81 | 1.83 | | 1.55 | 1.33 | | 2.66 | 186.67 | 30.0 | 297.50 | | | | 5.0 | 64. | 34.50 |
| (d) Headgates or Intake | | | | | | | | | | .25 | | .20 | 2.00 | | 1.60 | 21.67 | | 16.25 | | | | | | |
| (e) Other General Hydraulic | 38.61 | | 11.11 | | | | | | | | | | | | | | | | | | | | | |
| (f) TOTAL GENERAL HYDRAULIC: | 109.92 | | 93.38 | 9.0 | | 4.5 | 25.70 | | 22.02 | 2.18 | | 1.75 | 5.33 | | 4.26 | 408.33 | 30.0 | 313.75 | 0 | 0 | | 5.0 | 64. | 34.50 |
| 14. WATER WHEELS AND AUXILIARIES: | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Runner | | | | 3.0 | | 1.5 | 16.32 | | 13.99 | 1.00 | | 2.39 | .89 | | .71 | | | | | | | | | |
| (b) Shut-off Valve | 35.74 | | 30.63 | | | | 113.07 | | 98.63 | 13.31 | | 10.67 | 4.25 | 24. | 8.20 | | | | | | | | | |
| (c) Turbine Gates or Needle Nozzle | 1.01 | | .86 | | | | | | | 2.69 | | 2.09 | 8.58 | 5. | 7.86 | 6.33 | | 4.75 | | | | | | |
| (d) Guide Bearings or Main Bearings | 8.28 | | 7.10 | | | | 7.62 | .07 | 6.67 | 26.05 | | 20.84 | 6.99 | 16. | 8.79 | 1.00 | | .75 | | | | 632.0 | 1.0 | 316.50 |
| (e) Thrust Bearing | 12.84 | 11.33 | 12.64 | | | | 79.56 | | 65.14 | 239.06 | | 101.25 | | | | 1.67 | | 1.25 | | | | | | |
| (f) Governor and Governor System | 1.58 | .08 | 1.48 | 9.0 | 5.7 | 7.35 | 5.15 | 55.62 | 12.33 | 36.31 | 7. | 22.65 | 6.36 | 3. | 5.61 | 21.67 | | 16.25 | | | | 10.0 | | 5.00 |
| (g) Pressure Regulator or Deflectors | 6.22 | | 5.13 | | | | 10.20 | | 8.30 | 4.63 | 8. | 5.31 | | | | 687.33 | 8.0 | 517.50 | | | | | | |
| (h) Draft Tube | 67.61 | | 57.95 | | | | 15.00 | | 12.85 | | 5. | 1.00 | | | | | | | | | | | | |
| (i) Lubrication System | | | | | | | .24 | | .21 | 99.16 | 65. | 92.33 | 14.54 | 14. | 14.43 | .66 | | .50 | | | | | | |
| (j) Vibration | 5.31 | | 4.55 | | | | | | | | | | | | | | | | | | | | | |
| (k) Seal Rings | | | | 9.0 | | 4.5 | | | | 2.51 | | 2.01 | | | | | | | | | | | | |
| (l) Inspection | 3.26 | 10.97 | 4.37 | 9.0 | 7.06 | 8.03 | 4.81 | | 4.14 | 4.81 | 15. | 4.65 | | 27. | 5.49 | 13.33 | 6.0 | 11.50 | | | | 3.0 | 7.0 | 5.00 |
| (m) General Overhauling and Replacement | 90.49 | 301.67 | 120.95 | | | | 2.00 | 1495.80 | 216.17 | 1137.80 | | 910.28 | | | | 126.67 | | 95.00 | | | | | | |
| (n) Other Causes | 25.13 | 2.95 | 21.96 | 6.0 | 1.10 | 1.55 | 627.33 | | 537.71 | 59.36 | | 47.49 | 46.28 | | 37.03 | | | | | | | | | |
| (o) TOTAL WATER WHEEL: | 257.49 | 329.70 | 267.80 | 36.0 | 13.86 | 24.66 | 884.30 | 1552.39 | 979.79 | 1618.50 | 100 | 1095.66 | 87.79 | 89. | 98.03 | 858.67 | 14.0 | 647.50 | 0 | 0 | | 645.0 | 8.0 | 356.5 |
| 15. GENERATOR AND APPURTENANCES: | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Vibration | | | | | | | | | | | | | | | | | | | | | | | | |
| (b) Lubrication or Oil Leakage | .66 | | .57 | | | | 10.00 | | 8.67 | | | | | | | | | | | | | | | |
| (c) Rotor or Field | 1.33 | | 1.14 | 2.0 | 9.35 | 5.67 | 15.45 | 31.57 | 17.75 | 11.38 | | 9.10 | 4.44 | | 3.55 | 26.67 | | 20. | | | | 1.0 | | .50 |
| (d) Armature Iron or Windings | .13 | | .28 | | | | | | | 8.39 | | 6.71 | | 431.0 | 86.20 | 2.00 | | 1.5 | 291.00 | | 194.00 | | | |
| (e) Exciter and Rheostats | 2.39 | 1.68 | 2.29 | | | | | | | 12.51 | 12 | 12.41 | 11.52 | 13.0 | 11.81 | | | | | | | | | |
| (f) Ventilation System | | | | | | | | 7.67 | 1.29 | 1.21 | 7 | 1.97 | | | | 10.67 | | 8.0 | | | | | | |
| (g) Cleaning | 16.83 | | 14.43 | | | | 15.67 | | 13.42 | 1.61 | 5 | 2.30 | 3.36 | 2.0 | 1.88 | | | | | | | | | |
| (h) Inspection | 2.00 | 2.17 | 2.02 | 11.0 | 5.95 | 8.47 | | | | 1.02 | | .81 | 2.03 | 5.0 | 2.62 | 1.00 | 6.0 | 2.25 | | | | | 7.0 | 3.50 |
| (i) Other Causes | 41.66 | .55 | 35.79 | 149.0 | 2.10 | 75.50 | .30 | 8.67 | 1.49 | .50 | | .40 | 2.18 | | 1.74 | | | | | | | 48.0 | | 24.00 |
| (j) TOTAL GENERATOR: | 65.23 | 4.40 | 56.52 | 162.0 | 17.40 | 89.70 | 41.41 | 47.91 | 42.33 | 38.64 | 24 | 35.71 | 23.52 | 455.0 | 109.82 | 40.33 | 6.0 | 31.75 | 291.00 | 0 | 194.00 | 49.0 | 7.0 | 28.00 |
| 16. TOTAL ALL CAUSES,- (13+14+15) | 431.66 | 334.10 | 417.70 | 207.0 | 31.26 | 119.07 | 954.45 | 1600.30 | 1044.16 | 1659.32 | 124 | 1352.25 | 116.64 | 544.00 | 202.09 | 1307.33 | 50.0 | 993.00 | 291.00 | 0 | 194.00 | 699.0 | 79.0 | 389.00 |
| 17. NUMBER OF UNITS COVERED | 1 | 1 | 1 | 1 | 1 | | 2 | 2 | 2 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | 2 | 1 | 1 | 1 |
| 18. AVERAGE OUTAGE HOURS PER UNIT | 431.66 | 334.10 | 417.70 | 207.0 | 31.26 | 119.07 | 475.73 | 800.15 | 522.08 | 414.83 | 31 | 338.07 | 58.32 | 272.00 | 101.05 | 653.67 | 24.0 | 496.50 | 145.50 | 0 | 97.00 | 699.0 | 79.0 | 389.00 |

*word of caution in studying and analyzing the report that has prefaced previous reports must again be emphasized, and the reader should bear in mind that care must be taken in the forming of conclusions, because a full knowledge of the factors which have caused large or unusual outages is necessary before direct comparisons of equipment can be made. Outages may be due to faulty design, installation or operation, but it is not practical to differentiate the contributing causes in a tabular report without an extensive supplementary explanatory history. In comparing results, therefore, care must be taken that injustice is not done to a manufacturer whose equipment may have been improperly installed or operated or that a poor machine, well maintained and operated is not put above a good machine which is improperly maintained and operated. The report as presented is a truly representative cross-section of general conditions and the results herein set down are average and what may be expected in practice over a period of time. The addition of each year's record of operation adds to the value of the report, because the irregularities of infrequent and periodical overhauls and renewals become smoothed out in the average of a long period of time and the final statistics represent the probable performance of the equipment in service.*

THE report for the year 1930 covers a total of 71 units installed in 31 plants and having a grand total of 1,651,380 hp. There are 33 vertical turbine units with a total rating of 772,480 hp., driving vertical generators rated at 613,200 kva. The horizontal shaft units were divided among four turbines with a total rating of 64,700 hp. and 34 impulse wheels with a total rating of 814,200 hp. driving 38 horizontal generators with a total rating of 673,919 kva. The vertical turbines range in size from 10,500 hp. to 44,000 hp. and average 23,000 hp. Speeds vary from 171.4 r.p.m. to 600 r.p.m., and static heads from 157 to 820 ft. The impulse wheels range in size from 9,500 hp. to 56,000 hp. with an average of 23,950 hp. Speeds vary from 143 r.p.m. to 514 r.p.m. and static heads from 880 ft. to 2,563 ft.

The following tabular data show the operation of the units for the year 1930 together with the previous six years of operation and present the total and average kilowatt-hours generated as well as the segregated outage hours listed in accordance with the cause of outage. Brief footnotes indicate the nature of unusual outages, but it has not been possible to include detailed explanations. The report is well worth the time required for its complete study and affords an illuminating insight into the reasons for outages. Some are of a minor nature but frequently recurring, others are major casualties. The former are generally subject to correction when their nature is determined and better performance of equipment will result. The latter cannot usually be forestalled and are in the nature of unforeseen accidents which are unpreventable.

The previous report increased the actual outage hours for the first year of operation on plants that were first started within the initial year and whose records covered a fraction of that year. This increase was in amount proportional to the fraction of the year previous to the starting of the plant. Inspection of the report will reveal the fact that in numerous cases the one item of outage during the first few months of operation has not been repeated over the following period of six or seven years. The result of "weighting" the amount of this outage does not approximate what would have occurred if the plant had operated for a few months longer.

TABLE V — ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

HORIZONTAL TURBINE INSTALLATIONS

| Plant Index Number | 21 | | | 22 | | | 23 | | |
|---|---|---|---|---|---|---|---|---|---|
| Year / Item — Cause | 5Yr.Avg | 1930 | 6Yr.Avg | 6Yr.Avg. | 1930 | 7Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. |
| 13. GENERAL HYDRAULIC CAUSES: | | | | | | | | | |
| (a) Ice or Trash | | | | | | | 1.56 | | 1.25 |
| (b) Floods | | | | | | | | | |
| (c) Penstock or Canal | 70.40 | | 58.66 | 118.83 | 4488.0[h] | 803.00 | 10.12 | | 8.10 |
| (d) Headgates or Intake | | | | | | | 3.00 | | 2.40 |
| (e) Other General Hydraulic | | | | 2.83 | | 2.43 | 7.94 | | 6.36 |
| (f) TOTAL GENERAL HYDRAULIC: | 70.40 | | 58.66 | 191.66 | 4488.0 | 805.43 | 22.63 | | 18.11 |
| 14. WATER WHEELS AND AUXILIARIES: | | | | | | | | | |
| (a) Runner | | | | 22.66 | | 19.43 | 21.55 | | 17.24 |
| (b) Shut-off Valve | | | | | | | 7.62 | | 6.09 |
| (c) Turbine Gates or Needle Nozzle | .50 | | .42 | | | | | | |
| (d) Guide Bearings or Main Bearings | 55.82 | 4.0 | 47.19 | | 7. | 4.14 | 1.72 | | 1.32 |
| (e) Thrust Bearing | | | | 3.67 | | 3.28 | | | |
| (f) Governor and Governor System | 6.52 | 8.5 | 6.85 | | 3. | .43 | | 4.9 | 4.55 |
| (g) Pressure Regulator or Deflectors | .20 | | .17 | 180.50 | | 154.71 | 4.46 | 1.37 | 3.02 |
| (h) Draft Tube | | | | | | | .31 | | .25 |
| (i) Lubrication System | 1.57 | | 1.31 | | | | | | |
| (j) Vibration | .60 | | .50 | | | | | | |
| (k) Seal Rings | 1.39 | | 1.16 | 2.67 | | 2.28 | 55.90 | 6.26 | 45.98 |
| (l) Inspection | 1.44 | | 1.20 | 4.0 | | 3.43 | .35 | | .28 |
| (m) General Overhauling and Replacement | | 3.0 | .50 | 362.85 | | 311.00 | | | |
| (n) Other Causes | 1.76 | | 1.45 | | | | 21.93 | | 17.55 |
| (o) TOTAL WATER WHEEL: | 69.83 | 15.5 | 60.77 | 580.25 | 10. | 498.71 | 117.30 | 12.52 | 96.34 |
| 15. GENERATOR AND APPURTENANCES: | | | | | | | | | |
| (a) Vibration | | | | | | | | | |
| (b) Lubrication or Oil Leakage | | | | | | | | | |
| (c) Rotor or Field | 2.24 | | 1.87 | 0.50 | | .43 | 1.85 | | 1.48 |
| (d) Armature Iron or Windings | 364.46 | | 303.71 | | | | 2.04 | | 1.63 |
| (e) Exciter and Rheostats | .18 | | .15 | 3.17 | 1. | 2.85 | .25 | | .20 |
| (f) Ventilation System | 14.86 | | 12.39 | 2.83 | | 2.43 | | | |
| (g) Cleaning | | | | 2.83 | | 2.43 | | | |
| (h) Inspection | .04 | 0.38 | .10 | .33 | | .28 | | | |
| (i) Other Causes | .62 | | 0.52 | .33 | | .28 | 1.66 | | 1.33 |
| (j) TOTAL GENERATOR: | 382.40 | 0.38 | 318.74 | 10.00 | 1. | 8.71 | 5.80 | | 4.64 |
| 16. TOTAL ALL CAUSES,- (13+14+15) | 522.63 | 15.89 | 438.17 | 781.90 | 4499.0 | 1312.86 | 145.73 | 12.53 | 119.09 |
| 17. NUMBER OF UNITS COVERED | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18. AVERAGE OUTAGE HOURS PER UNIT | 261.32 | 7.94 | 219.08 | 781.90 | 4499.0 | 1312.86 | 145.73 | 12.53 | 119.09 |

h - Rebuilding canal to accommodate increased supply of water.

TABLE VI-A-ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

IMPULSE WATER WHEEL INSTALLATIONS

| Plant Index Number | 31 | | | 32 | | | 33 | | | 34 | | | 35A | | | 35B | | | 35C | | | 36A | | | 36B | | | 36C | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year / Item — Cause | 4Yr.Avg. | 1930 | 5Yr.Avg. | 2Yr.Avg. | 1930 | 3Yr.Avg. | 6Yr.Avg. | 1930 | 7Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 2Yr.Avg. | 1930 | 3Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 5Yr.Avg. | 1930 | 6Yr.Avg. | 5Yr.Avg. | 1930 | 6Yr.Avg. |
| 13. GENERAL HYDRAULIC CAUSES: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Ice or Trash | | | | | | | 205.00 | | 175.71 | | | 6.00 | | | | | | | | | | | | | | | | | | |
| (b) Floods | | | | | | | | | | 7.5 | | 41.20 | | | | | | | | | | | | | | | | | | |
| (c) Penstock or Canal | .24 | | .59 | | | | 73.67 | 13.0 | 65.00 | 53.5 | | | | | | 190.75 | | 152.60 | 36.0 | | 24.0 | 224.37 | 241.17 | 227.73 | 95.47 | 26.97 | 84.05 | 14.88 | 31.67 | 18.00 |
| (d) Headgates or Intake | | | | | | | 133.31 | | 114.29 | | | | | | | | | | | | | | | | | | | | | |
| (g) Other General Hydraulic | | | | | | | | | | 2.0 | | 1.60 | 36.42 | | 29.13 | 33 | | 27 | | | | | | | | | | 2.87 | | 2.10 |
| (f) TOTAL GENERAL HYDRAULIC: | .24 | | .59 | | | | 412.00 | 13.0 | 355.00 | 61.0 | 0. | 48.8 | 36.42 | | 29.13 | 191.08 | | 152.96 | 36.0 | | 24.0 | 224.37 | 241.17 | 227.73 | 95.47 | 26.97 | 84.05 | 17.75 | 31.67 | 20.40 |
| 14. WATER WHEELS AND AUXILIARIES: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Runner | 45.02 | | 36.02 | 131.81 | 236.0 | 166.54 | 32.00 | 620.0 | 116.00 | | | | 89.33 | | 71.46 | 303.92 | 7.0 | 244.53 | | 275.0 | 91.67 | 213.22 | 481.104 | 266.79 | .20 | 121.76 | 20.45 | 19.68 | 1094.60 | 198.84 |
| (b) Shut-off Valve | .14 | | .18 | 18.45 | | 12.30 | | | | 13.25 | | 10.60 | | | | | | | | | | .69 | | .55 | 30.28 | | 25.21 | 63.87 | | 32.89 |
| (c) Turbine Gates or Needle Nozzle | 4.23 | | 3.38 | 15.24 | 45.0 | 25.16 | 13.50 | | 31.57 | 40.38 | 14.0 | 15.10 | 41.00 | | 32.80 | 10.00 | | 8.0 | 22.00 | 6.0 | 16.66 | 10.00 | 14.62 | 27.35 | 10.67 | | 9.10 | 9.44 | 24.96 | 12.02 |
| (d) Guide Bearings or Main Bearings | | 34.0 | 6.80 | 3.27 | 7.0 | 4.52 | — | | | 64.38 | 21.0 | 55.76 | 36.50 | | 29.20 | | | | | | | 2.30 | | 1.84 | .92 | | .76 | 1.71 | | 1.42 |
| (e) Thrust Bearing | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (f) Governor and Governor System | 21.06 | 36.0 | 24.05 | 4.48 | 3.0 | 3.99 | | 1.0 | .14 | 23.50 | 7.0 | 20.20 | 1.00 | | .80 | | | | 111.00 | 2.0 | 74.67 | 23.90 | 20.02 | 23.12 | 10.37 | 5.84 | 9.62 | 4.54 | 4.65 | 4.55 |
| (g) Pressure Regulator or Deflectors | 46.95 | | 37.56 | 2.31 | | 1.54 | | | | 41.12 | 18.0 | 32.39 | | | | | | | 5.00 | | 3.33 | 18.44 | 16.25 | 17.99 | 4.78 | | 3.98 | 1.40 | | 1.17 |
| (h) Draft Tube | 14.20 | | 11.36 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (i) Lubrication System | | | | | | | | | | 14.75 | | 27.80 | | 3.0 | .60 | .50 | | 4 | | | | | | | | | | | | |
| (j) Vibration | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (k) Seal Rings | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (l) Inspection | 83.54 | 93.0 | 85.43 | 37.98 | 92.0 | 55.99 | 51.50 | 23.0 | 4.57 | 9.62 | 5.0 | 8.70 | 4.58 | 4.0 | 6.07 | 7.92 | 1.0 | 6.93 | | 35.0 | 11.66 | 14.28 | 27.14 | 16.86 | 8.11 | 14.67 | 9.20 | 9.19 | 18.08 | 10.67 |
| (m) General Overhauling and Replacement | 207.91 | | 166.32 | | | | 13.83 | | 11.86 | 185.00 | | 148.00 | 274.11 | | 219.47 | 86.42 | | 69.13 | | | | 74.12 | 154.57 | 89.81 | 29.61 | 10.12 | 29.75 | 2.43 | | 2.32 |
| (n) Other Causes | | | | | | | | | | 4.88 | | 3.90 | | | | | | | | | | .23 | | .19 | .69 | | .88 | .96 | | .72 |
| (o) TOTAL WATER WHEEL: | 423.05 | 163.0 | 371.84 | 213.56 | 383.0 | 270.04 | 60.83 | 644.00 | 144.14 | 416.88 | 59.0 | 345.10 | 448.74 | 7.0 | 360.40 | 408.76 | 10.0 | 349.00 | 138.00 | 383.0 | 219.67 | 377.08 | 711.69 | 444.72 | 95.30 | 172.59 | 108.10 | 111.1 | 1142.29 | 284.85 |
| 15. GENERATOR AND APPURTENANCES: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Vibration | 3.27 | | 2.62 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (b) Lubrication or Oil Leakage | | | | | | | | | | 10.75 | 1.0 | 8.80 | | | | | | | | | | | | 1.31 | | | | | | |
| (c) Rotor or Field | 81.84 | 729.0 | 211.27 | 6.51 | 16.0 | 9.67 | | | | 180.50 | | 144.40 | 4.50 | | 3.66 | | | | 6.0 | | 4.0 | 1.64 | | | 1.75 | | 1.46 | 1.2 | | 1.0 |
| (d) Armature Iron or Windings | 1.31 | | 1.04 | | | | 1.00 | | .86 | 125.50 | | 100.00 | 535.00 | | 428.00 | | | | | | | | | | | | | 31.0 | 169.00 | 56.33 |
| (e) Exciter and Rheostats | .56 | | .68 | | 13.0 | 4.33 | | | | 25.75 | | 20.60 | 60.25 | 3.0 | 48.80 | 28.25 | | | | | | 1.36 | | 1.09 | .54 | | .45 | 1.5 | | 1.13 |
| (f) Ventilation System | 2.00 | | 1.60 | | | | | | | | | | | | | | | 22.60 | | | | | | | | | | | | |
| (g) Cleaning | 40.70 | | 32.56 | 6.17 | 42.0 | 18.12 | 2.17 | | 1.86 | 30.00 | 7.0 | 25.40 | 7.33 | 1.0 | 6.07 | 1.67 | | 2.93 | | | | 41.50 | 13.0 | 36.80 | 26.00 | 24.00 | 25.67 | 22.30 | | 22.66 |
| (h) Inspection | 45.43 | | 36.34 | | | | 1.67 | | 1.41 | 21.12 | | 16.90 | .67 | | .53 | 11 | | .27 | | | | 12.00 | 1.95 | 10.30 | 16.50 | | 13.00 | 12.50 | 1.97 | 10.20 |
| (i) Other Causes | 2.88 | | 2.30 | 62.48 | | 41.65 | 4.11 | | 3.23 | 12.50 | | 10.00 | 15.00 | | 12.50 | 10.25 | | 8.20 | | | | | 50.68 | 10.13 | .80 | | .56 | 4.71 | .96 |
| (j) TOTAL GENERATOR: | 180.29 | 729.0 | 290.02 | 75.16 | 71.0 | 61.77 | 9.17 | 0 | 7.86 | 405.62 | 8.0 | 325.10 | 672.75 | 4.0 | 539.00 | 42.50 | 0 | 34.00 | 6.0 | | * 4.0 | 56.50 | 69.57 | 53.11 | 45.85 | 24.00 | 42.24 | 72.45 | 175.70 | 90.07 |
| 16. TOTAL ALL CAUSES,- (13+14+15) | 604.08 | 892.0 | 661.64 | 288.72 | 454.0 | 343.81 | 482.0 | 657.0 | 507.00 | 883.50 | 67.0 | 720.20 | 1157.91 | 11.0 | 928.53 | 642.34 | 10.0 | 515.87 | 180.0 | 383.0 | 247.66 | 658.85 | 1022.43 | 731.56 | 236.66 | 223.56 | 234.48 | 203.83 | 1351.66 | 395.13 |
| 17. NUMBER OF UNITS COVERED | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18. AVERAGE OUTAGE HOURS PER UNIT | 201.36 | 297.0 | 220.55 | 144.36 | 227.0 | 171.90 | 482.0 | 657.0 | 507.00 | 441.75 | 34.0 | 360.10 | 578.96 | 5.5 | 464.27 | 642.34 | 10.0 | 515.87 | 180.0 | 383.0 | 247.66 | 329.42 | 511.22 | 365.78 | 236.66 | 223.56 | 234.48 | 203.83 | 1351.66 | 395.13 |

i - Penstock joints. l - Re-bucketing.
j - Housing baffles.
k - General overhauling.

TABLE VI-B-ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

IMPULSE WATER WHEEL INSTALLATIONS

| Plant Index Number | 37A | | | 37B | | | 37C | | | 37D | | | 38 | | | 39 | | | 40 | | | 41A | 41B | 42 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year / Item — Cause | 6Yr.Avg. | 1930 | 6Yr.Avg. | 6Yr.Avg. | 1930 | 7Yr.Avg. | 1929 | 1930 | 2Yr.Avg. | 1929 | 1930 | 2Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 4Yr.Avg. | 1930 | 5Yr.Avg. | 3Yr.Avg. | 1930 | 4Yr.Avg. | 1930 | 1930 | 1929 | 1930 | Avg. |
| 13. GENERAL HYDRAULIC CAUSES: | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Ice or Trash | 2.21 | | 1.84 | 7.00 | | 6.00 | | | | | | | | | | | | | | | | | | | | |
| (b) Floods | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (c) Penstock or Canal | 4.14 | 755.26 | 129.33 | 86.67 | 755.26 | 189.18 | 11. | | 5.5 | 11.00 | | 5.5 | 394.00 | | 315.19 | | | | 5.21 | 40.25 | 11.99 | 481.* | | 16.6 | 25.50 | 21.05 |
| (d) Headgates or Intake | 1.62 | | 1.35 | 1.50 | | 1.28 | | | | | | | 7.10 | | 5.68 | 16.81 | 14.1 | 16.27 | | | | | | | | |
| (g) Other General Hydraulic | 9.60 | | 7.84 | 5.66 | | 4.96 | | | | | | | | | | | | | 2.27 | | .71 | | | | | |
| (f) TOTAL GENERAL HYDRAULIC: | 16.66 | 755.26 | 139.76 | 100.83 | 755.26 | 195.42 | 11. | 0 | 5.5 | 11.00 | 0 | 5.5 | 401.10 | 0 | 320.87 | 16.81 | 14.1 | 16.27 | 7.50 | 40.25 | 12.69 | 481. | | 16.6 | 25.50 | 21.05 |
| 14. WATER WHEELS AND AUXILIARIES: | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Runner | 179.20 | 469.15 | 227.52 | | | | 1256.0 | 507.67 | 881.83 | | | | 165.90 | | 132.72 | | | | 2.67 | 110.00 | 29.50 | | | 132.0 | 2.67 | 67.33 |
| (b) Shut-off Valve | 6.34 | 4.65 | 5.06 | 6.20 | | 5.32 | | 128.21 | 64.12 | 74.0 | | 17.0 | | | 1.46 | | | | | | | | | | | |
| (c) Turbine Gates or Needle Nozzle | 29.24 | 28.42 | 22.47 | 28.72 | 26.12 | 27.96 | 9.0 | | 4.50 | 36.0 | 18.57 | 27.28 | 46.55 | 7.28 | 40.91 | | 241.9 | 48.38 | 7.67 | 6.00 | 7.25 | | | 168.30 | 23.30 | 91.80 |
| (d) Guide Bearings or Main Bearings | 1.36 | 12.20 | 1.47 | .18 | | .16 | 41.0 | 32.10 | 36.61 | | | | | 16.13 | 4.62 | .05 | 41. | 9.64 | | | | | | 28.90 | | 14.45 |
| (e) Thrust Bearing | | | | | | | | | | | | | | 21.00 | | | | | | | | | | | | |
| (f) Governor and Governor System | 17.55 | 12.54 | 16.21 | 17.71 | 11.19 | 16.77 | 26.0 | 22.72 | 24.36 | 21.0 | 1.50 | 11.34 | 7.11 | 123.11 | 16.71 | 1.10 | .37 | .95 | | | | | | | | |
| (g) Pressure Regulator or Deflectors | .85 | | .71 | 7.16 | | 6.11 | | | | 6.0 | | 5.0 | 5.20 | | 4.16 | | | | .11 | | .25 | | | | | |
| (h) Draft Tube | | | | | | | | | | | | | | | | | | | 5.00 | 86.00 | 25.25 | | | | | |
| (i) Lubrication System | | | | | | | | | | 14.0 | | 7.0 | | | | | | | | | | | | | | |
| (j) Vibration | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (k) Seal Rings | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (l) Inspection | 52.60 | 26.84 | 48.11 | 11.92 | 17.36 | 29.91 | 15.0 | 4.68 | 9.84 | 15.0 | 5.10 | 10.65 | 1.00 | | 8.40 | .50 | | .40 | .67 | | .50 | | | 140.90 | 98.38 | 119.64 |
| (m) General Overhauling and Replacement | | 277.09 | 17.09 | 82.50 | 172.39 | 58.97 | | | | | 271.92 | 175.99 | | 617.11 | 123.43 | | | | | | | | | | | |
| (n) Other Causes | 16.32 | | 12.45 | 21.38 | | 14.74 | 48.0 | | 34.0 | | 14.48 | 9.93 | | | | | 3.00 | .40 | 113.16 | | 92.82 | | | 36.08 | | 18.00 |
| (o) TOTAL WATER WHEEL: | 304.46 | 770.84 | 402.11 | 180.77 | 548.99 | 416.19 | 1100.0 | 695.38 | 1054.20 | 168.0 | 309.84 | 268.89 | 227.96 | 760.15 | 336.32 | 1.65 | 297.27 | 58.77 | 149.50 | 202.00 | 162.82 | | | 541.60 | 124.15 | 332.97 |
| 15. GENERATOR AND APPURTENANCES: | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (a) Vibration | | | | | | | | 43.67 | 21.84 | | | | | | | | | | | | | | | | | |
| (b) Lubrication or Oil Leakage | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (c) Rotor or Field | 13.24 | .75 | 16.35 | 15.77 | 1.23 | 13.69 | 1.0 | 257.31 | 130.12 | 4.0 | 5.61 | 4.81 | 24.93 | | 19.94 | | | | 1.70 | | 2.62 | | | 801.50 | | 400.75 |
| (d) Armature Iron or Windings | 172.43 | | 144.11 | 5.72 | | 4.69 | | | | | | | 92.00 | | 73.60 | 14.97 | | 11.98 | 146.67 | | 110.00 | | | | | |
| (e) Exciter and Rheostats | 1.38 | | 1.16 | .79 | | .67 | | | | | | | | 1.00 | .80 | | 53.0 | 10.71 | | | | | | | | |
| (f) Ventilation System | | | | | | | | | | | | | | | | | | | | | | | | | | |
| (g) Cleaning | 32.54 | | 27.13 | 46.71 | | 40.11 | | | | | | | 1.20 | 143.28 | 29.62 | | 57.1 | 11.42 | | | | | | | | |
| (h) Inspection | 75.06 | 14.09 | 56.91 | 17.81 | 17.43 | 18.51 | 5.0 | 1.35 | 4.09 | 5.0 | 4.82 | 4.91 | .55 | | .40 | | | | | 30.0 | 7.50 | | | 169.30 | | 80.15 |
| (i) Other Causes | 11.92 | 10.42 | 11.62 | 11.58 | 16.97 | 11.93 | 66.0 | 42.11 | 54.06 | 80.0 | 14.28 | 57.13 | 51.11 | | 41.30 | | | | | | | | | 102.0 | 198.65 | 150.32 |
| (j) TOTAL GENERATOR: | 306.53 | 24.95 | 273.87 | 117.88 | 53.63 | 103.61 | 72.0 | 344.44 | 210.11 | 89.0 | 24.71 | 66.85 | 172.79 | 144.28 | 167.01 | 14.97 | 110.1 | 14.45 | 149.0 | 30.0 | 111.76 | | | 209.19 | 30.0 | 231.07 |
| | | | | | | | | | | | | | | | | | | | | | | | | 126.80 | 198.65 | 730.22 |
| 16. TOTAL ALL CAUSES,- (13+14+15) | 667.59 | 1571.02 | 818.16 | 379.21 | 1333.38 | 615.53 | 1503.0 | 1041.61 | 1272.31 | 268.0 | 374.57 | 321.28 | 801.87 | 934.43 | 828.38 | 33.43 | 413.7 | 109.48 | 456.17 | 272.25 | 410.18 | 483. | | 1822.00 | 348.50 | 1085.25 |
| 17. NUMBER OF UNITS COVERED | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 4 | 4 | 4 |
| 18. AVERAGE OUTAGE HOURS PER UNIT | 333.80 | 785.51 | 409.08 | 189.60 | 666.69 | 257.77 | 1503.0 | 1041.61 | 1272.31 | 268.0 | 374.57 | 321.28 | 200.47 | 233.61 | 207.09 | 33.43 | 413.7 | 109.48 | 456.17 | 272.25 | 410.18 | 483 | | 455.50 | 87.13 | 271.32 |

e - Improving efficiency
r - Shut-off valve trouble.
s - Cleaning and painting penstock inside.
m - Repairs to tunnel.
n - Re-bucketing.
p - First general overhauling.
p - Repairs to tunnel.

TABLE VII-A—ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

| Item — Cause | Vertical Turbines — Hours | | | Impulse Water Wheels — Hours | | | Horizontal Turbines — Hours | | | All Hydro-Electric Units — Hours | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1929 Total | 1930 | 1930 Total | 1929 Total | 1930 | 1930 Total | 1929 Total | 1930 | 1930 Total | 1929 Total | 1930 | 1930 Total |
| 13. GENERAL HYDRAULIC CAUSES: | | | | | | | | | | | | |
| (a) Ice or Trash | 127.82 | 4.08 | 131.90 | 1283.06 | 0. | 1283.06 | 6.25 | 0. | 6.25 | 1417.13 | 4.08 | 1421.21 |
| (b) Floods | 0. | 0. | 0. | 30.00 | 0. | 30.00 | | 0. | 0. | 30.00 | 0. | 30.00 |
| (c) Penstock or Canal | 2244.55 | 378.40 | 2622.95 | 5106.16 | 2374.08 | 7480.24 | 1525.50 | 4488.00 | 6013.50 | 8876.21 | 7240.48 | 16116.69 |
| (d) Headgates or Intake | 111.01 | 196.65 | 307.66 | 912.73 | 14.10 | 926.83 | 12.00 | 0. | 12.00 | 1035.74 | 210.75 | 1246.49 |
| (e) Other General Hydraulic | 1760.00 | 0. | 1760.00 | 253.60 | 0. | 253.60 | 48.78 | 0. | 48.78 | 2062.38 | | 2062.38 |
| (f) TOTAL GENERAL HYDRAULIC: | 4243.38 | 579.13 | 4822.51 | 6585.55 | 2388.18 | 9973.73 | 1592.53 | 4488.00 | 6080.53 | 13421.46 | 7455.31 | 20876.77 |
| 14. WATER WHEELS AND AUXILIARIES: | | | | | | | | | | | | |
| (a) Runner | 4973.01 | 4197.98 | 9170.99 | 6116.52 | 4044.51 | 10161.03 | 222.20 | 0. | 228.20 | 11311.73 | 8242.49 | 19554.22 |
| (b) Shut-off Valve | 1385.55 | 72.38 | 1457.93 | 704.92 | 140.16 | 845.08 | 30.47 | 0. | 30.47 | 2120.94 | 212.54 | 2333.48 |
| (c) Turbine Gates or Needle Nozzle | 225.75 | 14.42 | 240.17 | 1493.19 | 459.22 | 1952.41 | 2.50 | 0. | 2.50 | 1721.44 | 473.64 | 2195.08 |
| (d) Guide Bearings or Main Bearings | 2548.76 | 115.22 | 2663.98 | 523.37 | 192.38 | 715.75 | 303.02 | 11.00 | 319.02 | 3380.15 | 318.60 | 3698.75 |
| (e) Thrust Bearing | 2181.35 | 11.23 | 2192.58 | | | | 23.00 | 0. | 23.00 | 2204.35 | 11.23 | 2215.58 |
| (f) Governor and Governor System | 586.49 | 96.30 | 682.79 | 904.51 | 254.16 | 1158.67 | 50.45 | 16.40 | 66.85 | 1541.45 | 366.86 | 1908.31 |
| (g) Pressure Regulator or Deflectors | 3075.55 | 370.97 | 3446.52 | 560.74 | 114.25 | 674.99 | 1097.75 | 1.37 | 1099.12 | 4734.04 | 486.59 | 5220.63 |
| (h) Draft Tube | 595.25 | 543.00 | 1138.25 | 56.80 | | 56.80 | 1.25 | 0. | 1.25 | 653.30 | 543.00 | 1196.30 |
| (i) Lubrication System | 1167.61 | 93.00 | 1260.61 | 155.00 | 3.00 | 158.00 | 7.85 | 0. | 7.85 | 1330.46 | 96.00 | 1426.46 |
| (j) Vibration | 36.28 | 0. | 36.28 | 0. | 0. | 0. | 3.00 | 0. | 3.00 | 39.28 | 0. | 39.28 |
| (k) Seal Rings | 779.59 | 1.00 | 780.59 | 0. | 0. | 0. | 246.59 | 7.26 | 252.85 | 1026.18 | 7.26 | 1033.44 |
| (l) Inspection | 383.28 | 85.41 | 468.69 | 1300.71 | 467.77 | 1768.48 | 32.60 | 0. | 32.60 | 1716.59 | 553.18 | 2269.77 |
| (m) General Overhauling and Replacement | 6556.52 | 4061.47 | 10617.99 | 3844.52 | 1686.35 | 5530.87 | 2177.00 | 1.00 | 2180.00 | 12578.04 | 5750.82 | 18328.86 |
| (n) Other Causes | 6056.48 | 4.05 | 6060.53 | 832.53 | 82.48 | 915.01 | 96.63 | 0. | 96.63 | 6985.64 | 86.53 | 7072.17 |
| (o) TOTAL WATER WHEEL: | 30551.47 | 9666.43 | 40217.90 | 26492.81 | 9444.28 | 35937.09 | 4299.31 | 38.03 | 4337.34 | 61343.59 | 16148.74 | 77492.33 |
| 15. GENERATOR AND APPURTENANCES: | | | | | | | | | | | | |
| (a) Vibration | 82.00 | 0. | 82.00 | 13.08 | 43.67 | 56.75 | 0. | 0. | | 95.08 | 43.67 | 138.75 |
| (b) Lubrication or Oil Leakage | 2132.20 | 3.35 | 2135.55 | 49.55 | 1.00 | 50.55 | 0. | 0. | | 2181.75 | 4.35 | 2186.10 |
| (c) Rotor or Field | 3026.67 | 44.68 | 3071.25 | 2336.62 | 1009.84 | 3346.46 | 21.60 | 0. | 21.60 | 5384.79 | 1054.52 | 6439.31 |
| (d) Armature Iron or Windings | 2032.55 | 431.00 | 2463.55 | 4782.03 | 168.00 | 4950.03 | 1830.44 | 0. | 1830.44 | 8645.02 | 599.00 | 9244.02 |
| (e) Exciter and Rheostats | 190.33 | 46.18 | 236.51 | 360.13 | 70.90 | 431.03 | 20.91 | 1.00 | 21.91 | 571.37 | 118.08 | 689.45 |
| (f) Ventilation System | 54.57 | 17.65 | 72.22 | 121.00 | | 121.00 | 91.32 | 0. | 91.32 | 266.89 | 17.65 | 284.54 |
| (g) Cleaning | 2127.64 | 227.32 | 2354.96 | 1392.82 | 319.38 | 1712.20 | 17.00 | 0. | 17.00 | 3537.46 | 546.70 | 4084.16 |
| (h) Inspection | 224.03 | 27.87 | 251.90 | 1344.91 | 244.08 | 1588.99 | 2.23 | 0.38 | 2.61 | 1571.17 | 272.33 | 1843.50 |
| (i) Other Causes | 1316.40 | 15.32 | 1331.72 | 1255.99 | 154.78 | 1410.77 | 11.27 | 0. | 11.27 | 2584.16 | 170.10 | 2754.26 |
| (j) TOTAL GENERATOR: | 11186.29 | 813.37 | 11999.66 | 11656.13 | 2011.65 | 13667.78 | 1995.27 | 1.38 | 1996.65 | 24837.69 | 2826.40 | 27664.09 |
| 16. TOTAL ALL CAUSES.- (13+14+15) | 45981.14 | 11058.93 | 57040.07 | 35734.49 | 11844.11 | 47578.60 | 7887.11 | 4527.41 | 12414.52 | 89602.74 | 27430.45 | 117033.19 |
| 17. NUMBER OF UNITS COVERED | | | | | | | | | | | | |
| 18. AVERAGE OUTAGE HOURS PER UNIT | | | | | | | | | | | | |

TABLE VII-B—ANALYSIS OF OUTAGE HOURS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

| Item — Cause | Vertical Turbines — Percent | | | Impulse Water Wheels — Percent | | | Horizontal Turbines — Percent | | | All Hydro-Electric Units — Percent | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1929 Total | 1930 | 1930 Total | 1929 | 1930 | 1930 Total | 1929 Total | 1930 | 1930 | 1929 | 1930 | 1930 |
| 13. GENERAL HYDRAULIC CAUSES: | | | | | | | | | | | | |
| (a) Ice or Trash | .278 | .037 | .231 | 3.590 | 0. | 2.697 | .079 | 0. | .050 | 1.581 | .015 | 1.214 |
| (b) Floods | 0. | 0. | 0. | .084 | 0. | .063 | 0. | 0. | 0. | .033 | 0. | .026 |
| (c) Penstock or Canal | 4.881 | 3.422 | 4.598 | 14.289 | 20.044 | 15.722 | 19.342 | 99.129 | 48.439 | 9.906 | 26.396 | 13.771 |
| (d) Headgates or Intake | .241 | 1.778 | .539 | 2.554 | .119 | 1.948 | .152 | 0. | .097 | 1.156 | .768 | 1.065 |
| (e) Other General Hydraulic | 3.827 | 0. | 3.085 | 0.710 | 0. | .533 | .618 | 0. | .393 | 2.302 | 0. | 1.762 |
| (f) TOTAL GENERAL HYDRAULIC: | 9.228 | 5.237 | 8.455 | 21.227 | 20.163 | 20.963 | 20.191 | 99.129 | 48.979 | 14.979 | 27.179 | 17.838 |
| 14. WATER WHEELS AND AUXILIARIES: | | | | | | | | | | | | |
| (a) Runner | 10.814 | 37.960 | 16.078 | 17.116 | 34.148 | 21.356 | 2.817 | 0. | 1.790 | 12.624 | 30.049 | 16.708 |
| (b) Shut-off Valve | 3.013 | .654 | 2.556 | 1.973 | 1.183 | 1.776 | .386 | 0. | .245 | 2.367 | .775 | 1.994 |
| (c) Turbine Gates or Needle Nozzle | .491 | .130 | .421 | 4.178 | 3.877 | 4.103 | .032 | 0. | .026 | 1.921 | 1.727 | 1.876 |
| (d) Guide Bearings or Main Bearings | 5.542 | 1.042 | 4.670 | 1.465 | 1.624 | 1.504 | 3.905 | .243 | 2.570 | 3.772 | 1.161 | 3.160 |
| (e) Thrust Bearing | 4.741 | .101 | 3.844 | 0. | 0. | 0. | 0.292 | 0. | .185 | 2.460 | .041 | 1.893 |
| (f) Governor and Governor System | 1.275 | .872 | 1.197 | 2.531 | 2.146 | 2.435 | .640 | .363 | .538 | 1.720 | 1.337 | 1.631 |
| (g) Pressure Regulator or Deflectors | 6.688 | 3.354 | 6.042 | 1.569 | .965 | 1.419 | 13.918 | .030 | 8.853 | 5.283 | 1.774 | 4.461 |
| (h) Draft Tube | 1.294 | 4.910 | 1.995 | .159 | 0. | .119 | .016 | 0. | .010 | .729 | 1.979 | 1.022 |
| (i) Lubrication System | 2.539 | .841 | 2.210 | .434 | .025 | .332 | .099 | 0. | .063 | 1.485 | .350 | 1.219 |
| (j) Vibration | .079 | 0. | .064 | 0. | 0. | 0. | .038 | 0. | .024 | .044 | 0. | .034 |
| (k) Seal Rings | 1.695 | .009 | 1.368 | 0. | 0. | 0. | 3.126 | .138 | 2.037 | 1.145 | .026 | .883 |
| (l) Inspection | .833 | .272 | .822 | 3.640 | 3.949 | 3.717 | .413 | 0. | .263 | 1.916 | 2.017 | 1.939 |
| (m) General Overhauling and Replacement | 14.258 | 36.726 | 18.615 | 10.757 | 14.238 | 11.625 | 27.602 | .066 | 17.560 | 14.037 | 20.966 | 15.661 |
| (n) Other Causes | 13.170 | .037 | 10.625 | 2.328 | .696 | 1.923 | 1.225 | 0. | .778 | 7.796 | .315 | 6.043 |
| (o) TOTAL WATER WHEEL: | 66.438 | 87.408 | 70.508 | 46.153 | 62.852 | 50.311 | 54.510 | .841 | 34.938 | 57.301 | 62.519 | 59.524 |
| 15. GENERATOR AND APPURTENANCES: | | | | | | | | | | | | |
| (a) Vibration | .178 | 0. | .144 | .037 | .369 | .119 | 0. | 0. | 0. | .106 | .159 | .119 |
| (b) Lubrication or Oil Leakage | 4.637 | .030 | 3.744 | .139 | .008 | .106 | 0. | 0. | 0. | 2.435 | .016 | 1.868 |
| (c) Rotor or Field | 6.582 | .404 | 5.384 | 6.539 | 8.526 | 7.033 | .274 | 0. | .174 | 6.010 | 3.844 | 5.502 |
| (d) Armature Iron or Windings | 4.420 | 3.897 | 4.319 | 13.382 | 1.418 | 10.404 | 23.208 | 0. | 14.744 | 9.648 | 2.184 | 7.899 |
| (e) Exciter and Rheostats | .414 | .417 | .415 | 1.008 | .599 | .906 | .265 | .022 | .176 | .638 | .430 | .599 |
| (f) Ventilation System | .118 | .159 | .127 | .339 | 0. | .254 | 1.158 | 0. | .736 | .298 | .064 | .243 |
| (g) Cleaning | 4.627 | 2.056 | 4.129 | 3.898 | 2.696 | 3.599 | .216 | 0. | .137 | 3.948 | 1.993 | 3.490 |
| (h) Inspection | .487 | .252 | .442 | 3.763 | 2.062 | 3.340 | .028 | .008 | .021 | 1.753 | .993 | 1.575 |
| (i) Other Causes | 2.870 | .139 | 2.335 | 3.515 | 1.307 | 2.966 | .149 | 0. | .095 | 2.884 | .620 | 2.353 |
| (j) TOTAL GENERATOR: | 24.334 | 7.355 | 21.037 | 32.619 | 16.985 | 28.727 | 25.298 | .030 | 16.083 | 27.720 | 10.304 | 23.638 |
| 16. TOTAL ALL CAUSES.- (13+14+15) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| 17. NUMBER OF UNITS COVERED | | | | | | | | | | | | |
| 18. AVERAGE OUTAGE HOURS PER UNIT | | | | | | | | | | | | |

TABLE XIII—INDEX TO HYDRO-ELECTRIC PLANTS
FOR REPORT ON
MECHANICAL RELIABILITY OF HYDRO-ELECTRIC UNITS
BY
HYDRAULIC POWER COMMITTEE, P.C.E.A.

| INDEX NO. | COMPANY | PLANT | WATERWHEEL MANUFACTURER | GENERATOR MANUFACTURER |
|---|---|---|---|---|
| | | VERTICAL TURBINES | | |
| 1 | California Oregon Power Co. | Copco No.2 | Allis-Chalmers | Westinghouse |
| 2 | California Oregon Power Co. | Prospect No.2 | Pelton | General Electric |
| 3 | Pacific Gas & Electric Co. | Hat Creek No.1 | Wellman-Seaver-Morgan | General Electric |
| 4 | Pacific Gas & Electric Co. | Hat Creek No.2 | Wellman-Seaver-Morgan | General Electric |
| 5 | Pacific Gas & Electric Co. | Pit River No.1 | Allis-Chalmers | Allis-Chalmers |
| 6 | Pacific Gas & Electric Co. | Pit River No.3 | Pelton | General Electric |
| 7 | San Joaquin Light & Power Corp. | Kerckhoff | Allis-Chalmers | Allis-Chalmers |
| 8 | San Joaquin Light & Power Corp. | Kern Canyon | Allis-Chalmers | Allis-Chalmers |
| 9 | Southern California Edison Co. | Big Creek No.3 | Wellman-Seaver-Morgan | Westinghouse |
| 10A | Southern California Edison Co. | Big Creek No.8-Unit 1 | I.P. Morris | General Electric |
| 10B | Southern California Edison Co. | Big Creek No.8-Unit 2 | Pelton | General Electric |
| 11 | Southern California Edison Co. | Kern River No.3 | Pelton | General Electric |
| 12A | Pacific Gas & Electric Co. | Big Bend-Units 1,2,3,4 | I.P.Morris | General Electric |
| 12B | Pacific Gas & Electric Co. | Big Bend-Units 5, & 6 | I.P.Morris | General Electric |
| 13 | Pacific Gas & Electric Co. | Melones | S.Morgan Smith | Westinghouse |
| 14 | Bureau of Power & Light | San Francisquito No.2 | Wellman-Seaver-Morgan | General Electric |
| 15 | Pacific Gas & Electric Co. | Spaulding No.1 | Pelton | General Electric |
| | | | | |
| | | HORIZONTAL TURBINES | | |
| 21 | California Oregon Power Co. | Copco No.1 | Allis-Chalmers | General Electric |
| 22 | Pacific Gas & Electric Co. | Wise | Pelton | Westinghouse |
| 23 | Southern Sierras Power Co. | Adams Main | Worthington | General Electric |
| | | | | |
| | | | | |
| | | IMPULSE WATERWHEELS | | |
| 31 | Pacific Gas & Electric Co. | Caribou | Allis-Chalmers | General Electric |
| 32 | Pacific Gas & Electric Co. | Feather River | Pelton | General Electric |
| 33 | Pacific Gas & Electric Co. | Spring Gap | Pelton | General Electric |
| 34 | Pacific Gas & Electric Co. | El Dorado | Allis-Chalmers | General Electric |
| 35A | Pacific Gas & Electric Co. | Drum - Units 1 & 2 | Pelton | Westinghouse |
| 35B | Pacific Gas & Electric Co. | Drum - Unit 3 | Pelton | Westinghouse |
| 35C | Pacific Gas & Electric Co. | Drum - Unit 4 | Pelton | Allis-Chalmers |
| 36A | Southern California Edison Co. | Big Creek No.1-Unit 1,2 | Allis-Chalmers | General Electric |
| 36B | Southern California Edison Co. | Big Creek No.1 Unit 3 | Allis-Chalmers | General Electric |
| 36C | Southern California Edison Co. | Big Creek No.1 Unit 4 | Pelton | Westinghouse |
| 37A | Southern California Edison Co. | Big Creek No.2 Unit 3,4 | Allis-Chalmers | Westinghouse |
| 37B | Southern California Edison Co. | Big Creek No.2 Unit 5,6 | Pelton | Westinghouse |
| 37C | Southern California Edison Co. | Big Creek No.2A Unit 1 | Allis-Chalmers | Westinghouse |
| 37D | Southern California Edison Co. | Big Creek No.2A Unit 2 | Pelton | Westinghouse |
| 38 | Southern California Edison Co. | Kern River No.1 | Allis-Chalmers | General Electric |
| 39 | Southern Sierras Power Co. | Poole | Pelton | General Electric |
| 40 | San Joaquin Light & Power Corp. | Balch | Allis-Chalmers | General Electric |
| 41A | Bureau of Power & light - Unit #4 | San Francisquito No.1 | Pelton | Westinghouse |
| 41B | Bureau of Power & Light - Unit #5 | San Francisquito No.1 | Allis-Chalmers | Allis-Chalmers |
| 42 | Hetch Hetchy Water Supply | Moccasin | Pelton | General Electric |
| | | | | |
| | | | | |
| | | | | |

The effect probably would have been a diversification of classes of outages rather than the increasing of the total of any one type of outage. A large number of the plants have records covering six or seven years and an actual average of hours of outage seems desirable at this time. For these reasons the report this year does not include "weighted" averages on outage hours.

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## *Factors Influencing the Selection of Type and the Design of Flow Line Conduits**

*As stated in the introduction to the 1928-29 report of the subcommittee on the design and construction of flow-line conduits, it is important that they be designed with the utmost care in order to obtain the required capacity at a minimum cost. Any errors of judgment in the design might result in a deficiency of capacity which would be costly to correct. Pressure conduits can be crowded beyond their capacity by accepting the greater losses of head, incident to increased velocity. This is not true in the case of flow-line or open conduits. The hydraulic gradient is practically fixed. The ordinary provision for freeboard is made for emergency operating conditions only, and not as a factor against errors of design.*

THE day for designing a ditch or a bench flume "oversize," or with "a little extra freeboard" to take care of uncertainties of design is past. This is said with all due respect to the designers and builders of the miles of older flow lines constructed in the past. Many of these lines are still in use; some of them have been enlarged and made a part of more extensive systems. All of them have served or still serve as a practical hydraulic laboratory to the engineer who cares to observe and study the phenomena of the flow of water under actual working conditions. Perhaps in no other field of hydraulic engineering are principles of hy-

* Report of subcommittee on flow-line conduits, hydraulic power committee, Engineering Section. J. W. Jourdan, chairman. S. F. Goghlan, J. R. Johnson, E. N. Murphy, A. C. Norton.

draulics modified and tempered by observation and experience to the extent necessary in the design of flow line conduits.

### Economic Considerations

The economic factors influencing the selection of type and the design of flow line conduits will be briefly given as follows:

*Topography—*

Topography has a marked effect on flow line conduit design, as the type selected depends to a certain extent on the length necessary to connect two or more points and this length may differ greatly for the different types. For example, bench flumes that of necessity follow the contour in a rough country are much longer than flumes built on a substructure or siphons that allow short cuts across gulches. Tunnels may be cut straight through intervening ridges. The type selected depends on the comparative cost between the points connected. Steep slopes would tend to dictate the selection of bench flume or pipe line in preference to open ditches.

*Required Capacity—*

The principal factors affecting capacity are: coefficient of friction, slope and the shape of the cross-section in contact with the water.

On the same slope and with the same coefficient of friction, a circle is the most efficient cross section for a closed conduit and a semi-circle for an open conduit. The semi-circle is the more efficient of the two from the standpoint of material required in the conduit, as it has twice the area in cross-section for the same length of wetted perimeter.

A study of the economics of the type selected also involves a consideration of decrease in capacity with increase of age, as it is found that the coefficiet of friction of most structures increases with age, consequently decreasing the carrying capacity.

Open ditches, lined or unlined, are usually selected where very large capacities are required. For smaller capacities, bench flumes or pipe lines might prove to be more economical than a ditch of equal capacity.

*Formation and Soil Conditions—*

This affects the design from the standpoint of excavation costs and leakage; if the conduit is in an excavated section, it covers danger from breaks, slides, erosion and drainage. In some cases opening up and disturbing the surface uncovers and opens drainage seams and causes slides and erosion. In locations where rock excavation is necessary for certain types, it may be advantageous to select types requiring little or no excavation, such as pipes or flumes supported above the ground.

On unstable soil the selection should be of a type having the greatest flexibility and, in case a break occurs, one having the greatest salvage value and enabling the quickest replacement. A type of construction resulting in a minimum of leakage becomes very important when soil conditions are not good. Particular attention should be given to the placing of footings to keep them free from wet soil.

*Altitude and Climate—*

The effect of altitude and climate pertains principally to aquatic growths, evaporation and frost action or freezing conditions. Freezing causes considerably more trouble in certain types of conduits than in others, especially in those types in which leakage is present. Open conduits at high altitudes experience trouble, caused by the accumulation of snow and ice.

*Relative Cost of Construction—*

First cost will affect the economics only partially. In determining costs, maintenance costs, operating costs, and life of the structure should be considered, together with any other factors entering the problem, which, when all are considered together, will give the lowest annual cost.

Consideration should be given to cost of equipment, ease of erection, weights of materials to be handled, kind of labor required and speed of construction. Another factor that often enters is taking care of surface drainage, which is necessary for certain types. Adaptability for later increase of capacity for incorporating a given conduit in a larger system, should also be considered in the selection of type with regard to costs.

*Relative Economy of Maintenance and Operation—*

This depends on freedom from leakage, accessibility for inspection or for applying protective coatings, deterioration, effect of expansion and contraction, quickness with which repairs may be made and the probable salvage value of the structure in case of a break. Reliability of service is a very important factor. A type of construction that lends itself to maintenance at periods of small demand should be selected.

*Relative Importance of Conduit—*

This affects the design in considering permanence, freedom from interruptions of service, maintenance and leakage. The head under which the conveyed water is used is indicative of the importance of a conduit. A conduit incapable of being bypassed in an emergency, thus conserving the use of a large part of the flow, must be designed and built with special care to insure its permanence and reliability of service.

*Value of Loss of Head—*

Conservation of head in a conduit is an economic problem. The object is to obtain the greatest available head at the least cost in the case of a hydro-electric project. The cost of saving a unit of head must be equated against the value of a unit of head. The capacity, or more accurately, the amount of water conveyed per year, and the unit value of power, determine the value of head. The cost of saving head is worked out by a number of designs, based on different types of conduit and various slopes of invert or hydraulic gradient. Transitions must be designed carefully to regain a maximum of head. Practical limitations are sometimes imposed on the problem by features along the line between terminal points.

*Necessity for Saving Water as Dictated by Other Interests—*

This depends on existing water rights, leakage in the conduit, evaporation and value of the water for power, irrigation or domestic use.

*Danger to Adjacent Structures—*

Danger to adjacent structures is caused by overflow, leakage, breaks and slides and other causes and these are influenced by topography and soil formation conditions at the site. The value of adjacent property and the extent to which the danger may extend, will determine what remedial measures are justified.

*Transportation Facilities Bearing on Construction and Later Operation—*

Consideration should be given to the necessary equipment required for construction and necessary to be kept on hand for repairs, the weight of the materials to be handled, accessibility of site, available roads and necessary road construction, available materials and labor, and ease of construction.

*Physical, Biological and Chemical Conditions of Conveyed Water—*

The condition of the water will largely govern the selection of type of conduit—whether it should be metal or con-

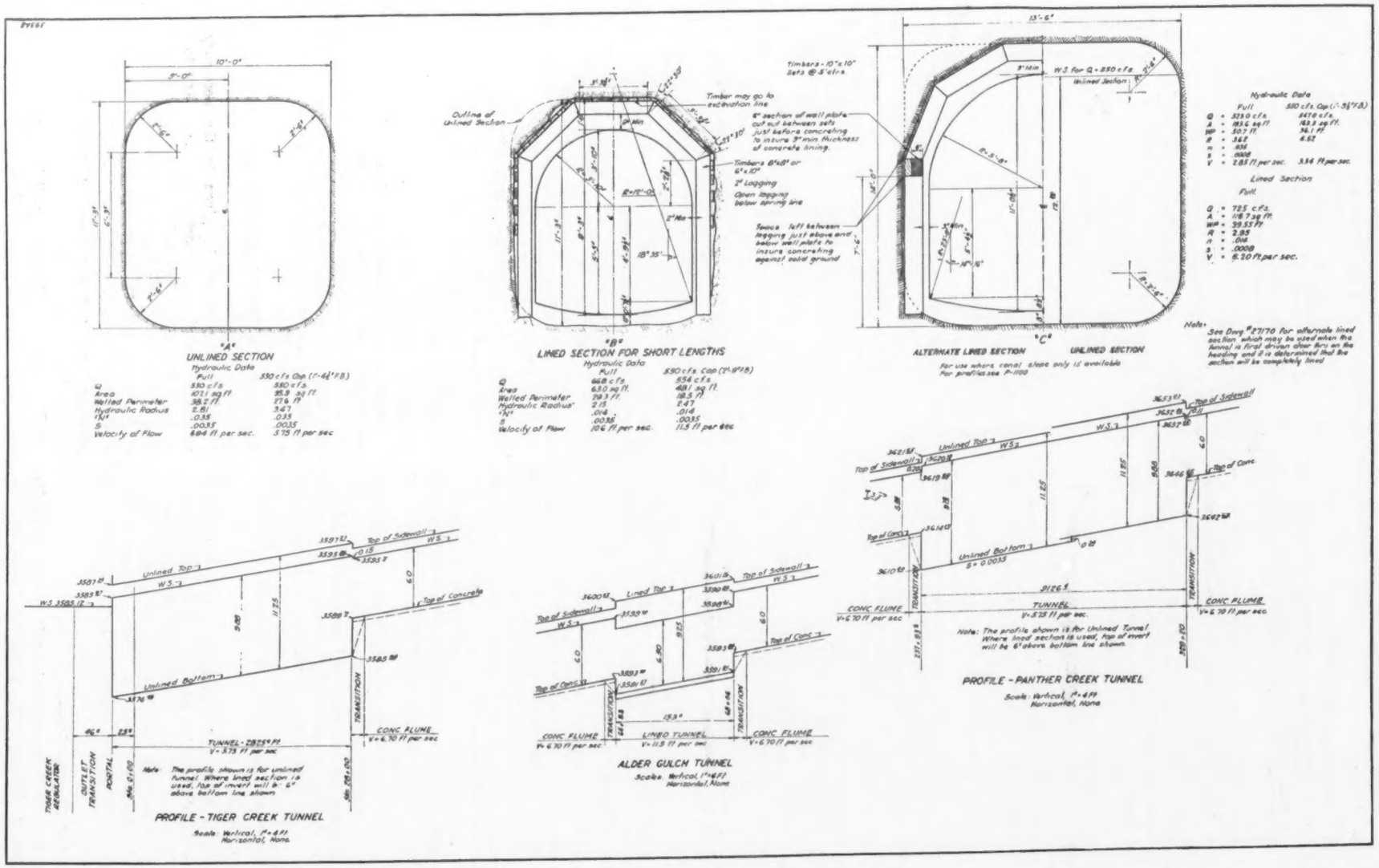

"A"
UNLINED SECTION
Hydraulic Data
Full
550 c.f.s. Cap (1'-4½" F.B.)
"B"
LINED SECTION FOR SHORT LENGTHS
Hydraulic Data
Full
590 c.f.s. Cap (1'-9" F.B.)
"C"
ALTERNATE LINED SECTION
UNLINED SECTION
For use where canal slope only is available
For profiles see P-1188
Timbers - 10"x10" Sets @ 5' c/c ms.
Timber may go to excavation line
6" section of wall plate cut out between sets just before concreting to insure 3" min. thickness of concrete lining.
Timbers 6"x8" or 6"x10"
2" Lagging
Open lagging below spring line
Space left between lagging just above and below wall plate to insure concreting against solid ground
Hydraulic Data
Full
550 c.f.s. Cap (1'-5½" F.B.)
Lined Section
Full
Note: See Dwg. #27170 for alternate lined section which may be used when the tunnel is first driven clear thru on the heading and it is determined that the section will be completely lined
PROFILE - TIGER CREEK TUNNEL
Scale: Vertical, 1" = 4 Ft
Horizontal, None
Note: The profile shown is for unlined tunnel. Where lined section is used, top of invert will be 6" above bottom line shown.
ALDER GULCH TUNNEL
Scale: Vertical 1" = 4 Ft
Horizontal, None
PROFILE - PANTHER CREEK TUNNEL
Scale: Vertical, 1" = 4 Ft
Horizontal, None
Note: The profile shown is for Unlined Tunnel. Where lined section is used, top of invert will be 6' above bottom line shown.
Unlined Top
Unlined Bottom
Top of Sidewall
Top of Concrete
Lined Top
TRANSITION
CONC FLUME
TUNNEL
TIGER CREEK REGULATOR
OUTLET TRANSITION
PORTAL

*Fig. 1. Typical sections and grades for tunnels on the Tiger Creek development, Pacific Gas and Electric Company.*

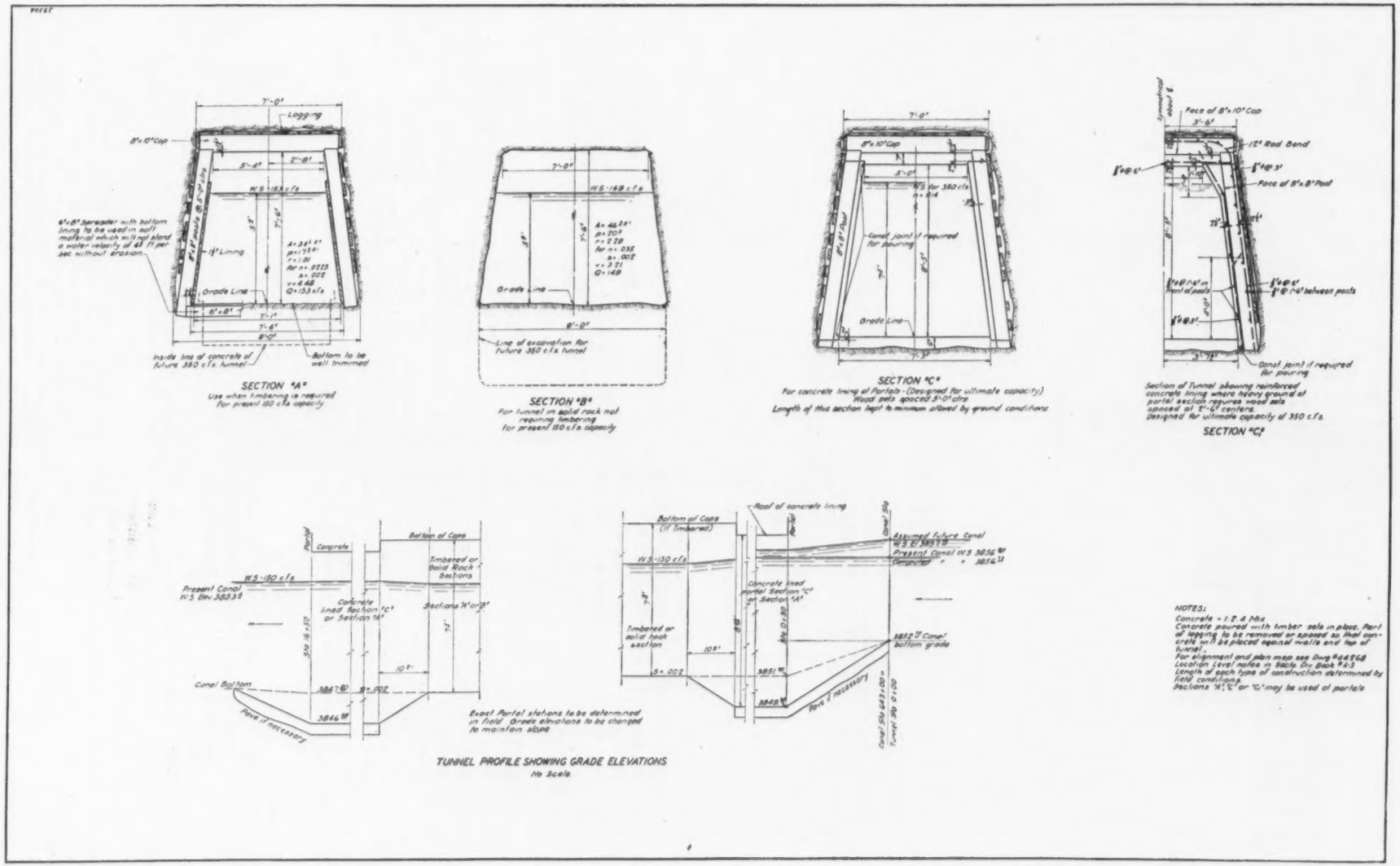

SECTION "A"
Use when timbering is required for present 150 c.f.s. capacity
SECTION "B"
For tunnel in solid rock not requiring timbering for present 150 c.f.s. capacity
SECTION "C"
For concrete lining at Portals - (Designed for ultimate capacity) Wood pets spaced 5'-0" ctrs
Length of this section kept to minimum allowed by ground conditions
Section of Tunnel showing reinforced concrete lining where heavy ground at portal section requires wood sets spaced at 5'-6" centers. Designed for ultimate capacity of 350 c.f.s.
SECTION "C"
TUNNEL PROFILE SHOWING GRADE ELEVATIONS
No Scale
Exact Portal stations to be determined in field. Grade elevations to be changed to maintain slope
NOTES:
Concrete = 1:2:4 Mix
Concrete poured with timber sets in place. Part of legging to be removed or spaced so that concrete will be placed against walls and top of tunnel.
For alignment and plan map see Dwg #44268
Location level notes in Sacto. Div. Book #83
Length of each type of construction determined by field conditions.
Sections "A", "B" or "C" may be used at portals

*Fig. 2. Sections and grade profile of Esmeralda tunnel, Eldorado Canal, Pacific Gas and Electric Company.*

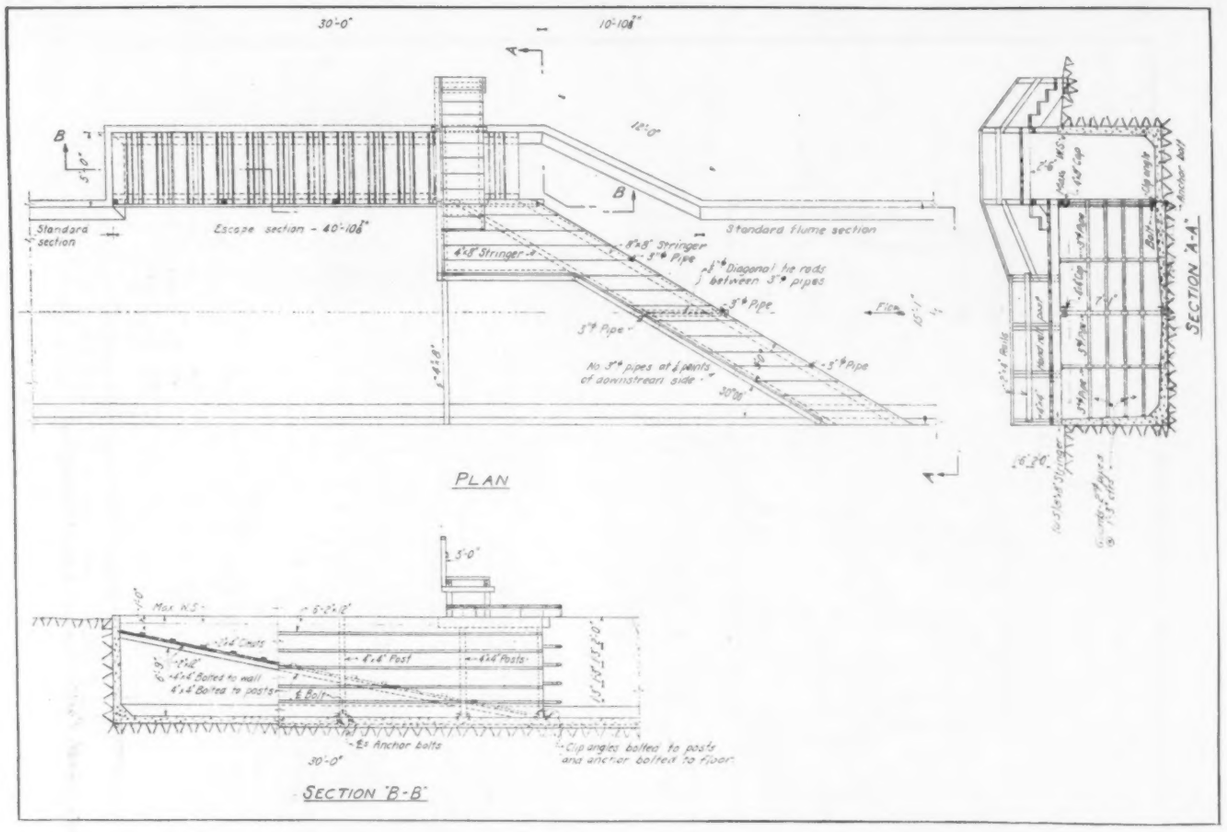



*Fig. 3. Deer escape in concrete flume, Tiger Creek development, Pacific Gas and Electric Company.*

crete, for instance. Adaptability and accessibility to the application of protective coatings, freedom from aquatic growths, smoothness of the interior surface (coefficient of friction), conditions as to scour from sand and gravel, and the velocity of the water should all be considered. Conduits designed for water known to produce aquatic growths must be designed with sufficient capacity to take care of the worst condition.

*Reconstruction and Enlargement of Conduit—*

The type to choose where reconstruction or enlargement of the type of conduit chosen is contemplated depends on the initial cost, the salvage of the conduit, facility of erection and removal, and the possibility of increasing the size of the original conduit.

The enlargement of an existing conduit would be governed by the same rules observed in the design of a new conduit. However, the freedom of choice of types and materials and the control of grade and alignment would be lacking.

*Estimated Life—*

To complete the study of the economics of the several types of conduit, it is necessary to take into consideration the estimated life of each type, in order to determine the annual cost or the capitalized cost for comparison, for only in this manner may a true comparison be obtained. In the final analysis, the annual cost of each structure consists of the interest on the investment, the annual maintenance and operating cost, the value of loss of head due to friction, the value of the leakage or evaporation losses, and the annual depreciation reserve required to replace the structure at the end of its estimated life. In order to make an accurate estimate of the life of any type of structure, it is necessary to examine as many as possible of the oldest existing structures of that particular type. Otherwise a very erroneous value may be used.

## Tiger Creek Conduit

Following is an outline, in general, of the information and tables furnished to the field engineer to enable him to make the field location of the 20-mile Tiger Creek conduit of the Pacific Gas and Electric Company on the Mokelumne River project.

### I—Type of Conduit Sections—550 Sec.-ft.

Outline drawings of the types of conduits which will be used are furnished. These drawings show, for bench flume, the hydraulic data, the amount of concrete per lineal foot of flume, the amount of excavation per lineal foot of flume for different degrees of ground slope and the cost per lineal foot based on these different degrees of ground slope. Additional cost per foot is allowed for flumes built on curves. The unit costs assumed for each item are also shown.

Corresponding units of cost are shown for other types of conduits.

*Types of Sections—*

Concrete bench flume
Elevated concrete flume
Tunnel, lined and unlined
Riveted steel siphon

### II—Controlling Elevations

The controlling elevation for making the final grade location is given as the maximum water surface of the Tiger Creek regulator at the lower end of the 550-sec.-ft. conduit (elevation 3,585). For locating the 600-sec.ft. conduit below the regulator, the water surface in the canal below is given as elevation 3,570.

### III—Limitations

Bench flume will be located with a minimum radius of 75 ft. and also be located with the floor on solid material. Elevated flumes will, in general, be located on tangent.

In determining the conduit grade, it is obviously necessary to allow for head losses in the transitions from one type of conduit to another. A table is given to the field engineer showing the rise or fall in the water surface in the transition from any given section

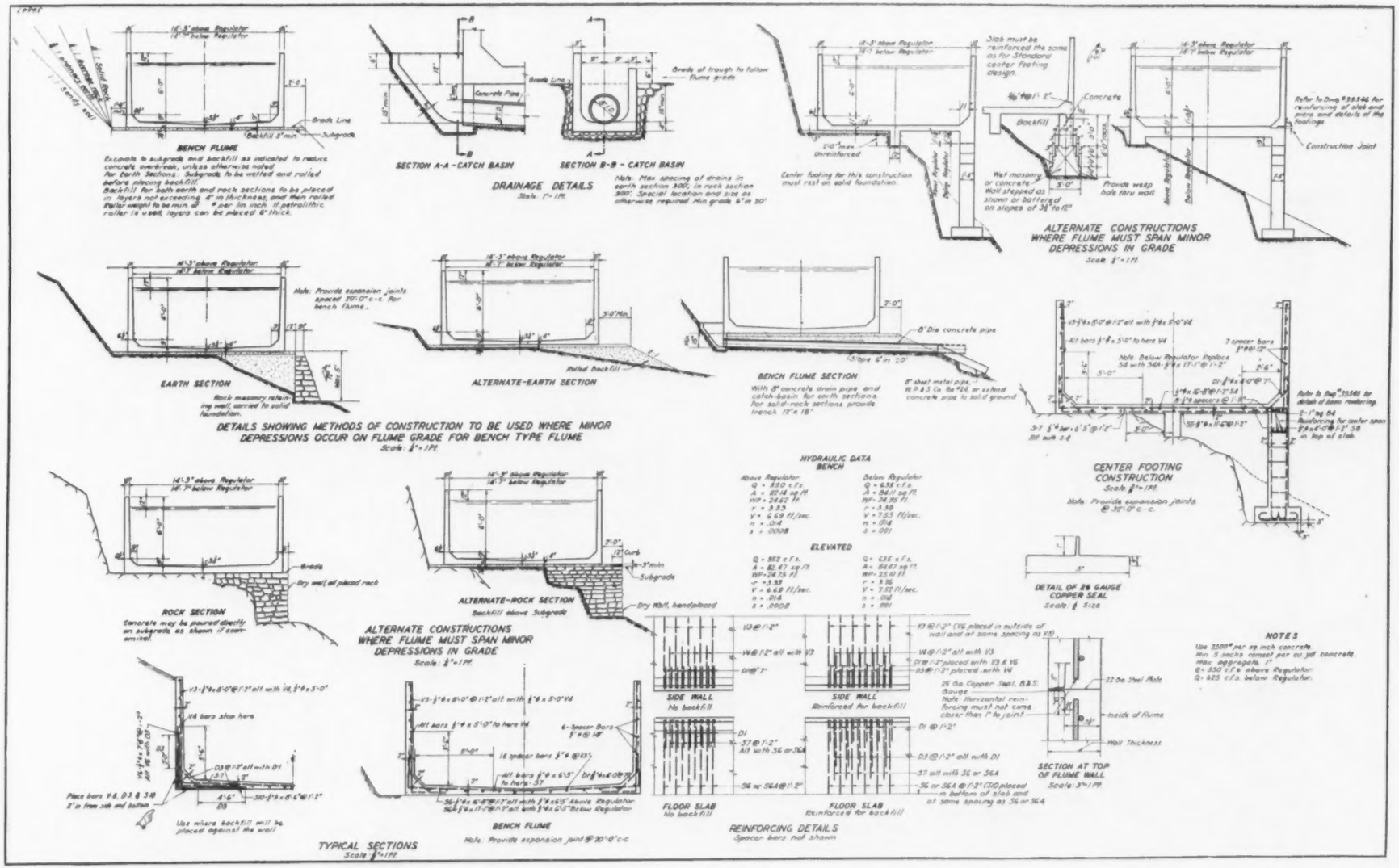



*Fig. 4. Flume details and reinforcing, Tiger Creek development, Pacific Gas and Electric Company.*

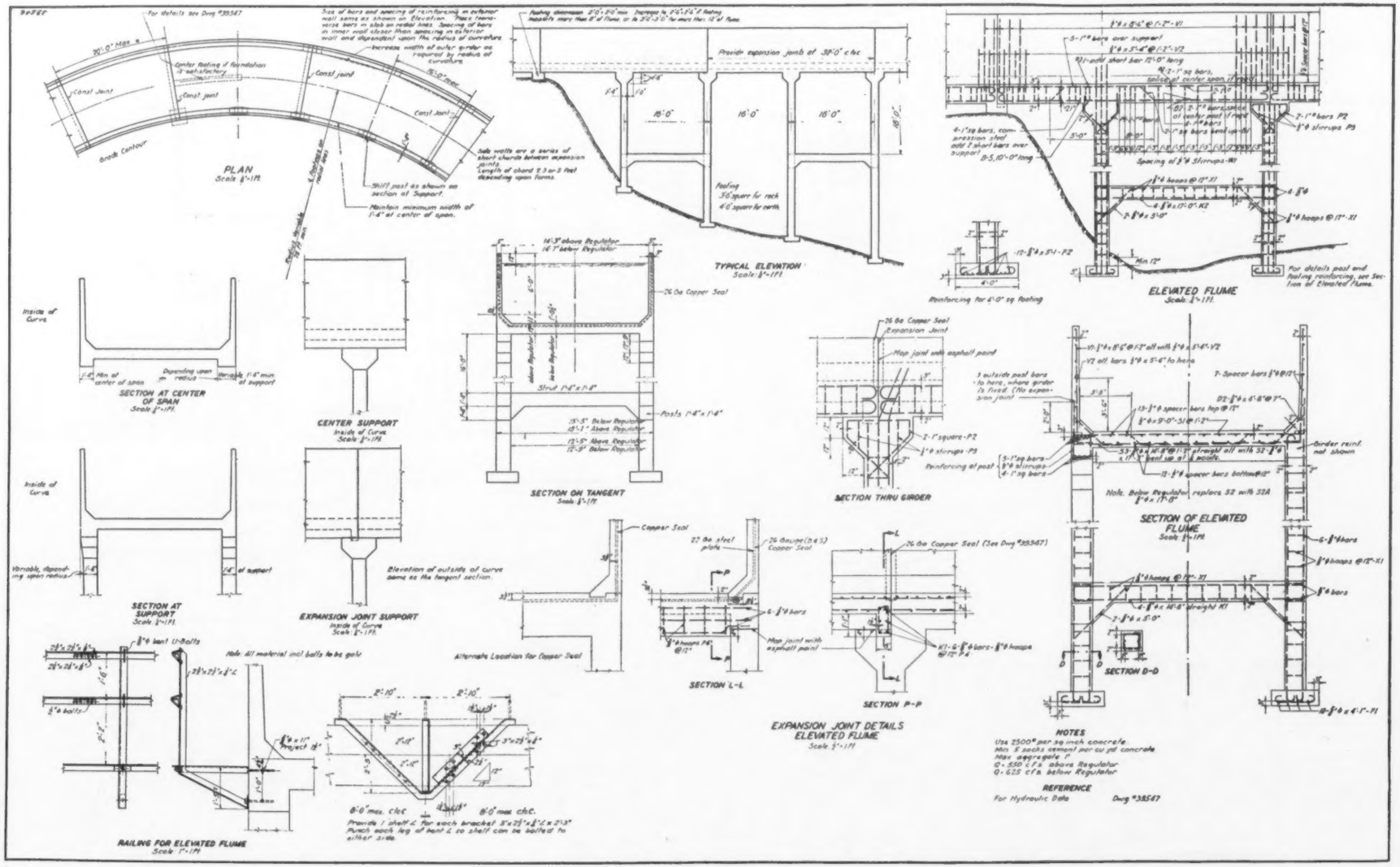



*Fig. 5. Flume details and reinforcing, Tiger Creek development, Pacific Gas and Electric Company.*

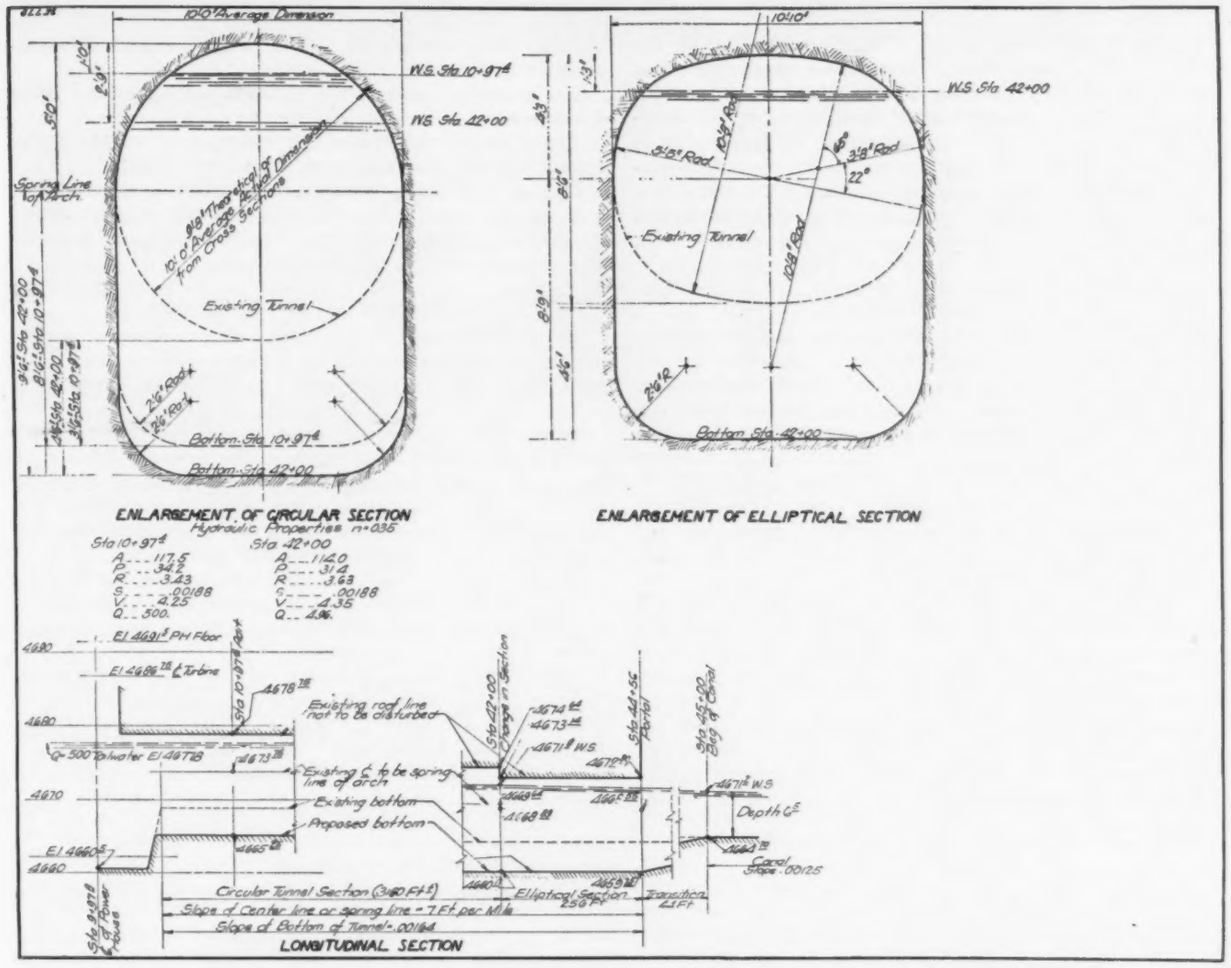



*Fig. 6. Sections for enlargment of outlet tunnel between Spaulding power house No. 1 and canal, Pacific Gas and Electric Company*

to any other section. The table is based on the following assumptions: For transition from lower to higher velocity, the head required = 1.05 ($h_v1 - h_v2$). For transition from higher to lower velocity, the head regained = 0.75 ($h_v - h_v2$).

IV—METHOD OF COMPARING ALTERNATE LOCATIONS FOR CONDUIT

The following set-up is made for each alternate route:

Item

1 Total construction cost.

2 Annual interest, depreciation and maintenance.

(a) Percentage of total cost for canals and tunnels (9 per cent).

(b) Percentage of total cost for pipe lines (10½ per cent).

3 Annual value of power lost due to friction and transition loss in conduit. This is obtained by multiplying total head loss in feet by the value of the output from 1 ft. of head.

4 To determine most economical location, obtain the total annual cost of each alternate location. Item (2) plus item (3).

In the original location of the Tiger Creek conduit of the Pacific Gas and Electric Company, a very steep topography was encountered just below the Salt Springs dam, at what is known as Amador Bald Rock. As construction work progressed and unit costs were checked, it was determined that, considering the certainty of obtaining solid rock in a tunnel at this point, giving an unlined section, and the safety from rock slides, a tunnel be driven on the same slope as the canal. This section is shown in Fig. 1 as Section "C." In such instances as the above, safety of operation is a factor, especially at altitudes where snow is a problem. In driving this tunnel, which was all solid work, satisfactorily low unit costs were obtained.

### BEAR RIVER CANAL

When enlarging the Bear River canal of the Pacific Gas and Electric Company, it was decided that the most economical method of increasing the canal capacity from 300 sec.-ft. to 475 and 450 sec.-ft. capacity, was to increase the water depth and completely line with gunite the outside bank, together with the bottom when necessary to prevent leakage. The canal was originally an earth section. Transportation facilities along the canal were poor and guniting lent itself better to the lining requirement. The freeboard on the outer bank was lacking in many sections and due to the difficulty of obtaining material to build the berm up, it was more economical to reinforce and extend the lining above the outer bank. Where it was necessary to extend the lining over a foot above the bank, a vertical reinforced tee wall was used to extend the lining. The lining was gunite, 1½ in. to 2 in. thick, reinforced with welded mesh.

Replacement of wooden flumes on the Bear River canal was made for the most part in concrete, with some metal flume where foundation conditions were unstable and solid formation hard to reach. The increase in relative importance of the conduit and the necessity of preventing leakage were also factors affecting the method of enlargement.

### OTHER CANALS

The same method as was used on the Bear River canal is being used in enlarging the company's Wise canal from 350 sec.-ft. capacity to 450 sec.-ft. capacity. This canal was also an earth section canal before the guniting of the outer embankment started.

In Fig. 2 are shown details of a tunnel located on the company's El Dorado canal. This tunnel eliminates about 2,700 ft. of canal. The grade of this tunnel is located with the idea of future enlargement of canal capacity. In determining the economics of this replacement, no first saving in cost was apparent in driving the tunnel, but the soil formation along the portion of canal eliminated by the tunnel was such that slides were of frequent occurrence both above and below the canal, giving no assurance of permanency, even if the canal sections were completely lined with gunite or concrete. The difficulty of keeping water out of the canal for any length of time, due to water demand, also had to be considered. An additional consideration was that a state highway is located just below the sliding ground along the canal. So other factors besides those of the economics of present cost, such as those of safety and ease of operation, enter into improvements and maintenance charges of power canals.

## General

In the case of the company's smaller power canals, the replacement of wooden flumes is a maintenance problem of importance. The effort is made in each case to determine the type of replacement by estimating the least annual cost for each alternative. No general rule can be given, as each problem has its own particular conditions. In the case of the older conduits, the matter of leakage losses has an important bearing.

Certain geographical locations require consideration of auxiliary structures. Where the Tiger Creek conduit passed through a game reserve, it was necessary to construct game crossings at selected points, with a considerable amount of fencing. Deer escapes as shown in Fig. 3 were also constructed in the canal.

The general details of the concrete section of the Tiger Creek conduit are shown in Figs. 4 and 5.

Fig. 6 shows the section for enlargement of the outlet tunnel between Spaulding power house and canal.

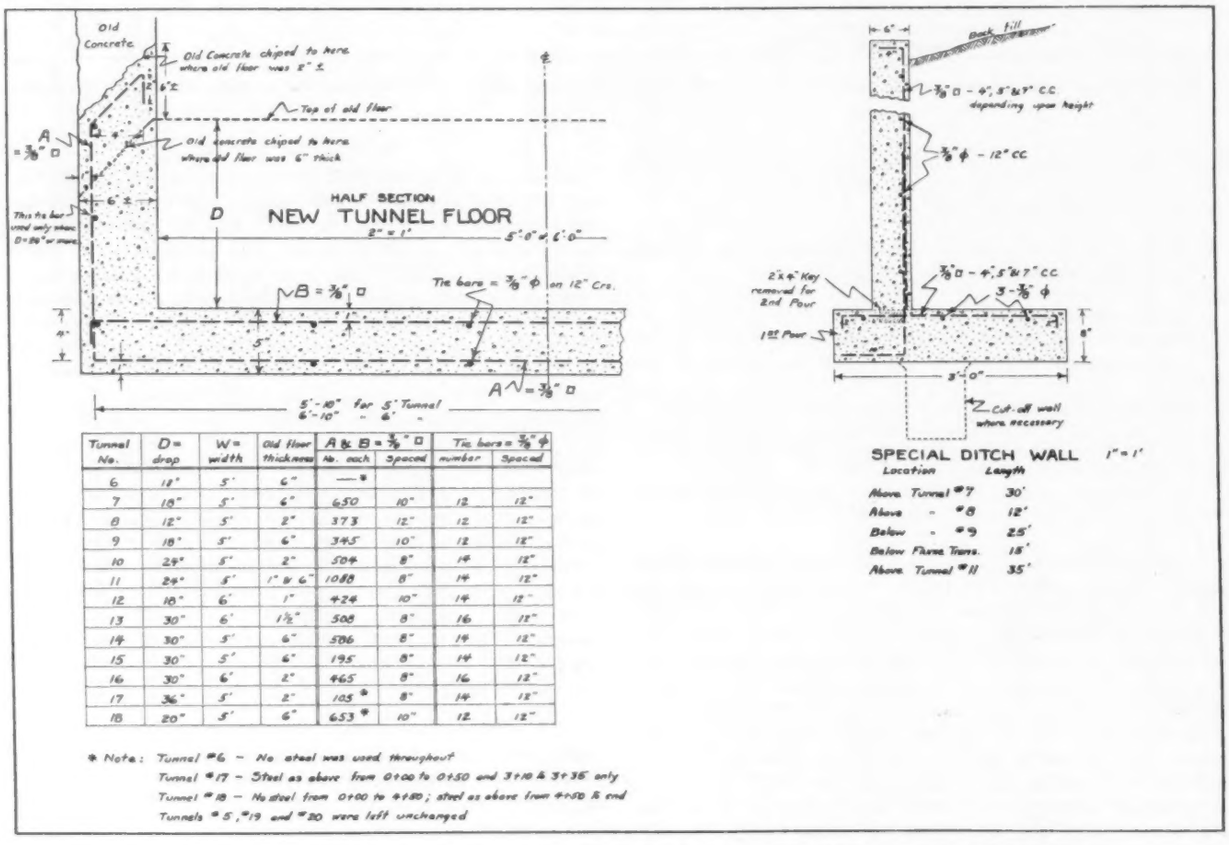
In Fig. 7 is shown the method of lowering the floors of a number of flow line tunnels to increase the capacity of the Crane Valley ditch No. 1 of the San Joaquin Light & Power Corporation from 135 sec.-ft. to 200 sec.-ft.

## Reference to Previous Reports

The subcommittee on flow line conduits reported on the design and construction of open canals and ditches, bench flumes and auxiliary structures in 1928-29. In 1929-30 this report was continued, to include the design and construction of flow tunnels and flow line pipes. These two reports necessarily contain considerable data on the economic factors involved, including discussions of formulas used, shape of sections, and co-efficient of roughness. In the present report, an effort was made to avoid repetition of information previously reported and conveniently available.

The bibliography on the subject has grown during the past two years, but is not included here, as most of the articles have been published by the technical magazines in reach of all P.C.E.A. members.

Specific reference is made, however, to Technical Bulletin No. 150, on the "Flow of Water in Riveted Steel and Analogous Pipes" by Fred C. Scobey, senior engineer of the Department of Agriculture. This is a late bulletin (January, 1930), and contains a great deal of experimental data, together with a comparison of old and new formulas.


Old Concrete
Old Concrete chipped to here where old floor was 2" ±
Top of old floor
Old concrete chipped to here where old floor was 6" thick
HALF SECTION
NEW TUNNEL FLOOR
2" = 1'
5'-0" & 6'-0"
Tie bars = ⅜" ϕ on 12" Crs.
B = ⅜" □
A = ⅜" □
5'-10" for 5' Tunnel
6'-10" " 6' "
Back fill
⅜" □ - 4", 5" & 7" C.C. depending upon height
⅜" ϕ - 12" C.C.
2"x4" Key removed for 2nd Pour
⅜" □ - 4", 5" & 7" C.C.
3 - ⅜" ϕ
1st Pour
3'-0"
Cut-off wall where necessary
SPECIAL DITCH WALL 1" = 1'
Location Length
Above Tunnel #7 30'
Above - #8 12'
Below - #9 25'
Below Flume Trans. 15'
Above Tunnel #11 35'

| Tunnel No. | D = drop | W = width | Old floor thickness | A & B = ⅜" □ No. each | Spaced | Tie bars = ⅜" ϕ number | Spaced |
|---|---|---|---|---|---|---|---|
| 6 | 18" | 5' | 6" | —* | | | |
| 7 | 18" | 5' | 6" | 650 | 10" | 12 | 12" |
| 8 | 12" | 5' | 2" | 373 | 12" | 12 | 12" |
| 9 | 18" | 5' | 6" | 345 | 10" | 12 | 12" |
| 10 | 24" | 5' | 2" | 504 | 8" | 14 | 12" |
| 11 | 24" | 5' | 1" & 6" | 1088 | 8" | 14 | 12" |
| 12 | 18" | 6' | 1" | 424 | 10" | 14 | 12" |
| 13 | 30" | 6' | 1½" | 508 | 8" | 16 | 12" |
| 14 | 30" | 5' | 6" | 586 | 8" | 14 | 12" |
| 15 | 30" | 5' | 6" | 195 | 8" | 14 | 12" |
| 16 | 30" | 6' | 2" | 465 | 8" | 16 | 12" |
| 17 | 36" | 5' | 2" | 105* | 8" | 14 | 12" |
| 18 | 20" | 5' | 6" | 653* | 10" | 12 | 12" |

* Note: Tunnel #6 - No steel was used throughout
Tunnel #17 - Steel as above from 0+00 to 0+50 and 3+10 & 3+35 only
Tunnel #18 - No steel from 0+00 to 4+80; steel as above from 4+50 & end
Tunnels #5, #19 and #20 were left unchanged

*Fig. 7. Reconstruction of new tunnel floor, ditch No. 1, San Joaquin Light & Power Corporation.*

# METER COMMITTEE REPORTS[1]

## *Education of Metermen**

*Two courses for metermen are planned this year as usual, one at Pasadena and one at Berkeley.*

TWO courses for metermen will be held in California this year. The short course to be held in the southern part of the state, March 23rd to 28th inclusive, at the California Institute of Technology, and the other course to be held at the University of California at Berkeley, May 18th to 23rd.

* Report of subcommittee on education of metermen, meter committee, Engineering Section, E. Ealson, chairman.

## *Meter Obsolescence**

*The subject of meter obsolescence has been studied this year largely from a standpoint of the practice of our member companies and their policies relative to the retirement of the older types of meters. An effort has been made to point out some of the fundamental improvements of modern meters. The subject has received very little discussion in the sessions of the meter committee and it is suggested that next year further agreement might be reached by thorough discussion, from which, perhaps, more definite policies may be established.*

THE advent during the past few years of watthour meters of new design by all meter manufacturers has presented to the operating meter departments of the utilities the question of retirement of the older types of watthour meters now in service.

It is generally agreed that the factors controlling meter obsolescence are somewhat intangible, and for this reason a standard program of retirement that would be uniformly applicable to all operating companies would be very difficult to formulate.

The subject might be divided into three separate studies, as follows:

1. *Retirement*—A definite policy of retirement might be the practice of certain utilities depending purely upon the age of the apparatus in question.
2. *Depreciation*—Depreciation implies the loss of value incurred largely due to the wear and tear upon the apparatus, or the decreased value due to continued operation.
3. *Obsolescence*—True obsolescence causes the replacement of old apparatus because it has been definitely superseded by apparatus of new and better design, which unquestionably makes further use of the old material impracticable. New inventions and radical improvements in the art and more perfect standardization are considered.

The present problem of watthour meter operation, with regard to the continued use of the old types of instruments, cannot be definitely handled under any one of the three subdivisions above. However, each of the three offers problems for discussion.

### Retirement

While some operating utilities have established a policy of removing the older types of meters from the line, it is largely because of the difficulty of obtaining repair parts and the increasing cost of these parts, or because of terminal positions which interfere with new and standard practice of meters and meter loop locations as left by the wiring contractor. It is generally agreed that, except for small temperature errors and overload characteristics, the old types of meters have retained their calibration with a remarkable degree of accuracy.

It might also be recalled that two member companies of the P. C. E. A. have paralleled old type and modern type meters in selected locations over a long period of time without appreciable difference in registration.

### Depreciation

From a consideration of our second subdivision, a policy of replacement would depend upon the wear and tear of the instrument. Of course, jewel bearings and top bearings are subject to replacement, perhaps several times during the useful life of the watthour meter, and would not necessarily enter into a retirement policy. However, the rust and deterioration of the cover and base, due to weathering and age, would have to be considered. Worn shaft bearing causes unpleasant noise and vibration, and affects the accuracy.

In certain climates the coil insulation may become brittle and break down. Here again cost of repair parts would have a definite bearing upon the policy of replacement and theoretically should not be in excess of the interest and depreciation charges.

### Obsolescence

From the third point of attack, I believe that all member companies agree that the modern meter is definitely superior to the older types in refinements. However, it does not basically put the older types in the discard. For instance, it is not as radically superior as the induction type meters were over the armature type. In the latter case, the advent of the induction type for a.c. service definitely showed the mistake of further use of the armature or motor type and soon replaced all of the latter type in service.

It is quite generally agreed that the following advantages of the modern types deserve very careful consideration.

Increased ratio of torque to weight of moving element, simplification of construction and ease of adjustment, improved temperature and overload characteristics, which, with increased use of appliances, requires serious consideration, glass covers, standardized terminal chambers with removable terminals and high maintained accuracy, the latter being largely due to improved materials and research work on the part of the manufacturer.

The subject will require numerous tests and diligent study upon the part of the operating companies, but when all of the factors are considered, it may be possible to set up an economic outline, definitely showing where savings can be made by the use of new meters in replacement of the old types, although these definite figures are difficult to compile.

In an effort to obtain operating practice in the P. C. E. A. territory, the following questionnaire was sent to all com-

* Report of subcommittee on meter obsolescence, meter committee, Engineering Section. F. A. Redding, chairman.

[1] W. A. McMeekin, Los Angeles Gas and Electric Corporation, chairman.
E. L. Hughes, Pacific Gas and Electric Company, vice-chairman.
Los Angeles Bureau of Power and Light: J. C. Albert, L. H. Ellerman.
Great Western Power Company: W. G. Knight.
Los Angeles Gas and Electric Corporation: M. A. Mason, M. A. Plummer.
Midland Counties Public Service Corporation: D. D. Smalley.
Pacific Gas and Electric Company: O. A. Knopp, W. M. Lindblad, G. H. Searle, N. P. Carlsen, Jr., R. Crowell, L. D. Tycer, J. C. Abel, E. M. Hart, R. C. Seagren.
Southern California Edison Company Ltd.: W. R. Frampton, L. H. Beebe, Lester L. Conrad, F. A. Redding, E. Ealson, J. H. Vivian, J. H. Dorsey.
San Diego Consolidated Gas & Electric Company: W. H. Talbott, C. F. Dalziel.
San Joaquin Light & Power Corporation: C. F. Gilcrest, G. A. Collins.
The Southern Sierras Power Company: R. G. Jones.
Duncan Electric Manufacturing Company: A. F. Blecksmith.
General Electric Company: Fred Garrison, C. R. Benson.
Leeds & Northrup Company: N. Cohn.
Sangamo Electric Company: J. G. Monahan, L. A. Nott.
States Electric Company: H. M. Thomas.
Weston Electrical Instrument Company: J. H. Southard.
Westinghouse Electric & Manufacturing Company: J. E. Bridges, W. F. Grimes.

TABLE I—Meter Obsolescence—Company Reporting.

| Question Number | a | b | c | d | e | f |
|---|---|---|---|---|---|---|
| 1..... | No | No | No | No | Yes | No |
| 2..... | Yes | Very little bearing. | Yes | Yes | Yes | Yes |
| 3..... | Influenced by age of meter. Repair not to exceed 67% of cost. | Influenced by age of meter. 5 yrs. or under, not to exceed 25%. Junked if over 15 yrs. | Not to exceed 25% of cost. | Influenced by age. Not to exceed 70% of replacement cost. | Influenced by age and characteristics. Only minor repairs on older styles. | Influenced by age. No amount stated. |
| 4..... | Yes Allowed to equal cost of new meter. | Yes | Yes Not to exceed 40% cost of new meter. | Yes Not to exceed 75% cost. | Yes | Yes |
| 5..... | No | Yes | Very little. | No | Yes | No |
| 6..... | No | Meters of this age are junked when trouble is found. | No | No | Yes | No |
| 7..... | No | Only on a few larger capacities. | No | No | No | No |

pany correspondents, the majority of whom answered, giving in detail their present practice:

1. Should length of service, regardless of mechanical and electrical condition, be paramount in determining the obsolescence of a watthour meter? Why?
2. Should the various terminal positions have a bearing on further service for a watthour meter? Why?
3. To what extent should repair costs influence the utility in retiring watthour meters? Why?
4. Should a more liberal repair allowance be made for new type as against old type meters? If so, to what extent?
5. Do you believe that there is a loss of revenue to the utility through the use of old meters with inferior overload and temperature characteristics?
6. Should meters twenty or more years of age be routined more frequently than those under that age? State reasons.
7. Due to the increased use of three-wire meters, do you consider it practical to convert two-wire meters to the three-wire type? Why?

The answers to the questionnaire have been tabulated in the attached table and the results show that, while in some cases there is an approximate agreement, still the practice is far from uniform. It is to be hoped that thorough discussion may be permitted at the group meetings next year, to bring out sufficient arguments and presentation of facts to reach a more definite policy of watthour meter retirement.

## *Reactive Kva. Metering**

*This year our committee has attempted to cover the problems connected with the practical application of Rkva. metering as applied to our various rate schedules. No attempt has been made to make an analysis of the correctness of various methods of connecting meters to record the Rkva. of three-wire and four-wire loads as ordinarily found. We would refer those who are interested in such an analysis to the 1929-30 report of the Great Lakes Division of the N.E.L.A. on "Reactive Volt-ampere Hour Measurement on Three-phase Circuits."*

*Special tests on the accuracy of Rkva. meters with unbalanced conditions of load and voltages have recently been performed in the testing laboratories of one of the member companies. From the standpoint of accuracy, it is accepted that very satisfactory results can be obtained in the measurement of power factor by comparing the readings obtained from two watthour meters, one measuring the Rkva. and the other the kilowatt component of the load, as long as the voltages are balanced. When the voltages are unbalanced, the error in the measurement of Rkva. depends upon the degree of voltage unbalance and the type of load.*

*Reports received to date from the various companies in California having power factor rate clauses in effect, show that unbalance of voltage has caused no trouble, and very little trouble has been encountered in applying the proper metering.*

*A number of interesting cases are likely to develop in the metering of Rkva., particularly in the interchange of power between two systems, such as may be had where the consumer has standby service of his own and operates in parallel with the utility system. In this case, as well as in the case where the consumer has sufficient corrective equipment to give leading power factor, ratchets must be installed on the Rkva. meter to prevent reversal. If the ratchet is not installed, the meter will run forward on lagging power factor and backward on leading power factor.*

*In the case where the consumer supplies his own transformers, and the Rkva. meter is connected on the high tension side, the magnetizing current taken by these transformers may affect the average power factor of the consumer's load. This factor should be considered, especially where the magnetizing current of the transformers is proportionately large compared with the load, resulting in a low power factor.*

*For companies contemplating Rkva. metering, it is highly recommended that the installations be standardized as much as possible. With the installations standardized, specific instructions can be prepared covering the checking of wiring and testing of the meter, thus avoiding all possible errors.*

REACTIVE kva. metering is used as a means of measuring the average power factor of a particular load over a definite time interval. From the ratio of the Rkva.-hours to kilowatt-hours recorded over a definite time interval, the average power factor or weighted average power factor is calculated and then applied to the rate schedule.

As defined by the A. I. E. E. standards, "The reactive volt-amperes in a circuit is the square root of the difference between the square of the apparent power and the square of the power."

In order to measure the Rkva. of polyphase loads, it is customary to use the regular polyphase meter. The potential elements of the polyphase meter are energized with volt-

* Report of subcommittee on Rkva. metering, meter committee, Engineering Section. E. L. Hughes, chairman.

ages numerically equal to but lagging 90 degrees from the voltages that we would ordinarily use to measure the kilowatt-hours. The necessary 90-degree displacement is readily obtained by means of phase displacement transformers. Taps are brought out in the windings of these transformers, so that the proper voltages and phase displacement are obtained when connected to the line.

Power factor may be expressed as the percentage of the current actually running the motor to the current actually flowing in the motor. In terms of energy supplied, power factor can also be expressed as the relation between the actual energy supplied in kilowatts and the apparent energy, if measured in kva.

Most power factor wastes are due primarily to a.c. motors of the induction type. This type of motor is magnetized and then demagnetized each time the current alternates; there is the magnetizing current which magnetizes the motor, as well as the running current which runs the motor and supplies the load. For a particular motor and load these two currents have definite phase relations with the voltage supplied, the running current being in phase with this voltage and the magnetizing current in quadrature and lagging. Since the induction type of motor cannot supply its own magnetizing current, the power company is called upon to furnish this part, provided the consumer does not have some form of power factor improving apparatus within his own plant.

The magnetizing current taken by induction type motors, being nearly constant at all loads, becomes proportionately large when the apparatus is lightly loaded. Thus it is seen that, with the apparatus loafing, if we may call it such, the power factor is inherently low and the current required for a given amount of power increases the size of the conductors, transformers, meters and other equipment to and including the generating plant itself.

With induction type motors properly loaded, the power factor is usually 80 per cent or better and may be considered satisfactory, but when the power factor drops below 70 per cent, which is not at all unusual, the heating effect of the current becomes excessive, the heating effect at 70 per cent power factor being nearly double that at 100 per cent power factor.

By careful selection of consumers' equipment, the average power factor can be maintained at a satisfactory figure; if synchronous motors, static condensers or other corrective devices are used, the power factor can be raised to 100 per cent or may be made leading.

The saving to the utility company through such increase in power factor to a satisfactory figure, justifies a reward, in that the apparent load on its facilities is reduced and hence its equipment is released for other service.

## Utility Company Power Factor Rate Clauses in Effect

### *Object of Such Rates*

The primary object of the so-called power factor clauses, with bonuses for high power factor or charges for low power factors, is not to collect money for reactive loads, but to restrict the amount of this reactive load, so as to avoid discrimination in the service charges to individual consumers, by equalizing the rates.

### *Power Factor Rate Clauses Adopted*

It has been generally accepted that any equitable rate plan for electrical service must take into consideration power factor or the reactive load. Within the last year several of the operating companies in California have recognized the importance of this factor in rate making, by changing their power rate schedules, thus equalizing the cost of service rendered to their individual consumers.

The power factor rate clauses adopted by the several companies differ in several respects and are shown as a matter of information:

*Company A*

On application by the consumer, where the maximum demand is not less than 250 kw., and where the kilowatt-hours consumed in any month exceed the lagging Rkva.-hours used in that month, a credit allowance on this schedule will be made on such excess kilowatt-hours at the rate of eight-tenths (0.8) of a mill per kilowatt-hour. A ratchet device will be installed on the Rkva. meter to prevent its reverse operation on leading power factors.

*Company B*

Upon application, consumers having an operating demand of 200 kw. or more and who maintain an average power factor during the month in excess of 75 per cent lagging, shall be allowed a discount on the total month's bill under "B" rate of 0.3 per cent for each 1 per cent that the monthly average power factor exceeds 75 per cent, to and including 85 per cent, plus 0.2 per cent discount for each 1 per cent that the monthly average power factor exceeds 85 per cent, with a maximum discount of 6 per cent for unity or leading power factors.

*Company C*

Reads essentially same as company B.

*Company D*

(d) Power Factor Clause: Where consumers have a total connected load of 500 hp. or more, charges for energy shall be adjusted for weighted monthly average power factor as follows:

If the power factor exceeds 80 per cent, bills shall be reduced by 0.3 per cent for each 1 per cent of such excess up to and including 90 per cent power factor and by 0.2 per cent for each 1 per cent of such excess over 90 per cent power factor. If the power factor is less than 65 per cent, bills shall be increased by 0.5 per cent for each 1 per cent of such deficiency in power factor, provided that the maximum increase shall not exceed 5 per cent. In no case, however, shall the total charge, after adjustment for power factor, be less than the minimum charge.

For determining the weighted monthly average power factor for the purpose of this schedule, a meter to measure the Rkva.-hours of the load shall be installed in conjunction with the watthour meter. The power factor, computed from the ratio of the monthly Rkva.-hours, to the monthly kilowatt-hours, shall be computed to the nearest whole per cent. In any case, where the power factor is likely to be leading at any time, the reactive component meter may be ratcheted to prevent reversal.

## Standardized Practice in Installation of Rkva. Meters

### *Standard Installations—*

In the application of the various power factor rate clauses, all of the companies were confronted with the problem of redesigning the installations affected, to include the necessary Rkva. meter, phasing transformers, test switches, etc. In addition to this, the companies having large numbers of such installations to make, had to standardize so as to avoid all possible errors in wiring. One company having over 300 Rkva. installations also standardized the phase sequence at the meter. This was thought advisable, as the installations on its system were scattered over some 8,500 sq. mi., making it necessary to depend upon a large group of men for wiring and checking the work.

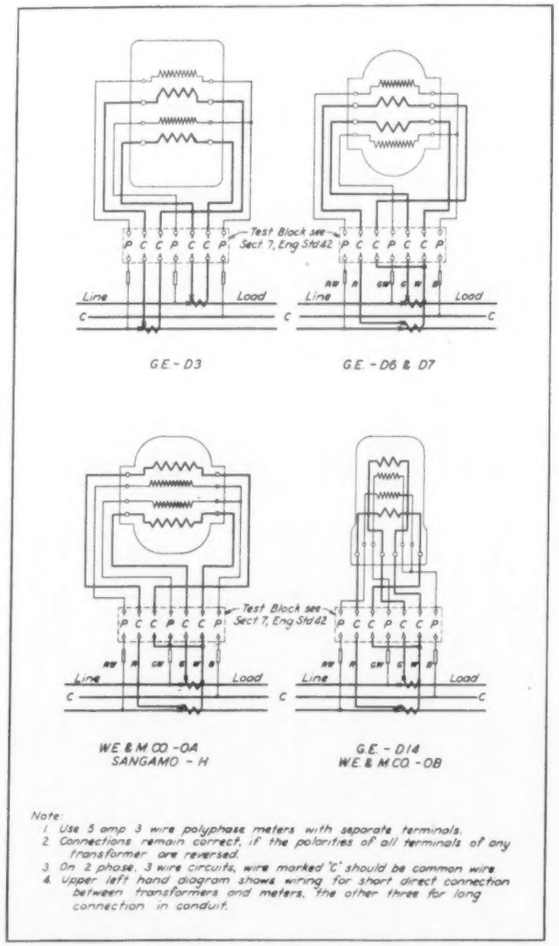
### *Standardized Drawings—*

Figs. 1-3 show some of the standardized drawings as prepared by company D for making the installations. Various types of phasing transformers were considered by this company. The type finally selected included the necessary phasing transformers built into a test block so that the potential connections on the Rkva. meter could be easily changed to the test position, thus simplifying the test on the meter. It will be noted that its drawings also show the proper phase sequence when using a phase sequence indicator. When the wiring on the installation between the test block and the instrument transformers has been corrected to give the proper rotation, it may be assumed that the Rkva. meter will run forward on lagging power factor without having to reverse the connections at the phasing transformer; thus, all of its installations are similar and can be easily checked at future periods for correctness of connections.

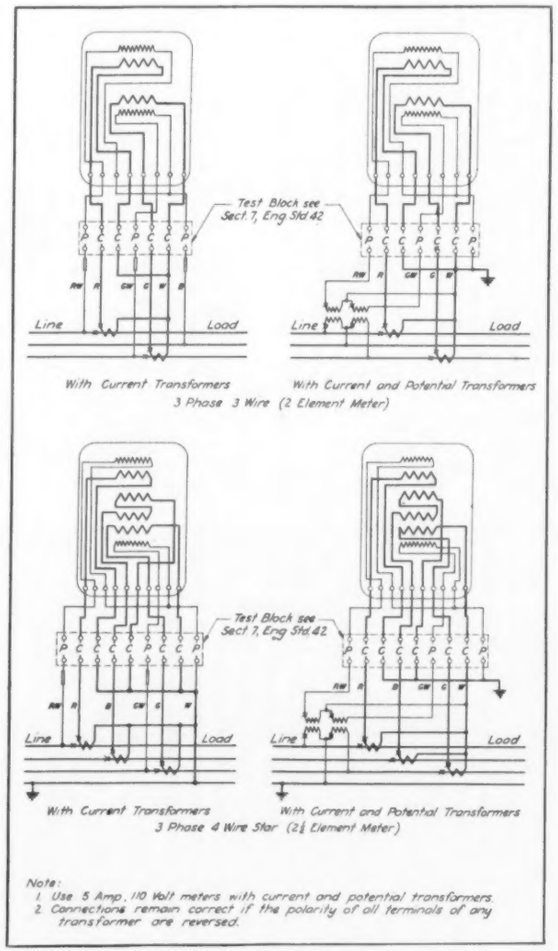
### *Department Installing Meters—*

In answer to the question, "Which department in your company installs Rkva. meters?", all of the companies re-

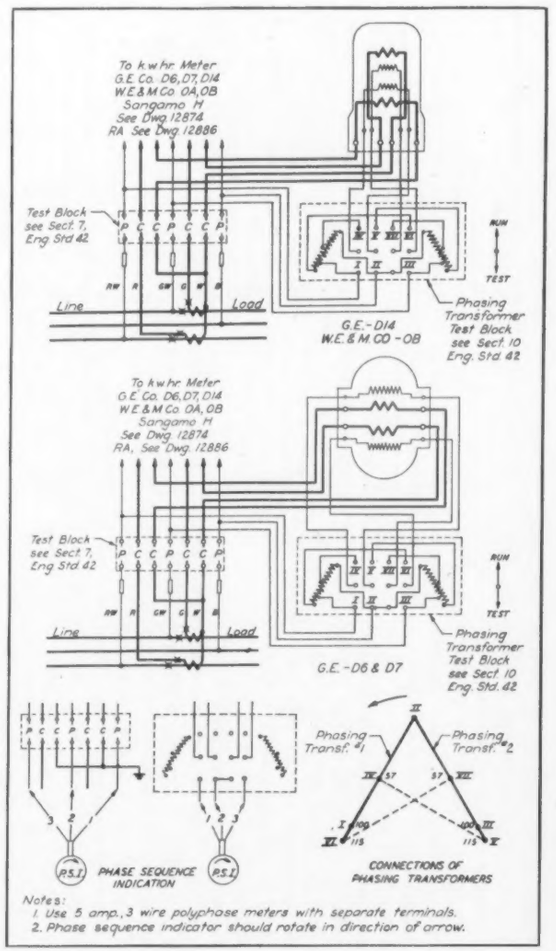
*Fig. 1. Standard drawings as prepared for company D for making installations to meet the requirements of the various power factor rate clauses*


Test Block see Sect. 7, Eng. Std 42
Line
Load
G.E. - D3
G.E. - D6 & D7
W.E. & M CO - OA
SANGAMO - H
G.E. - D14
W.E. & M CO - OB
Note:
1. Use 5 amp. 3 wire polyphase meters with separate terminals.
2. Connections remain correct, if the polarities of all terminals of any transformer are reversed.
3. On 2 phase, 3 wire circuits, wire marked 'C' should be common wire.
4. Upper left hand diagram shows wiring for short direct connection between transformers and meters, the other three for long connection in conduit.

*Connections for metering two or three-phase three-wire loads with current transformers.*

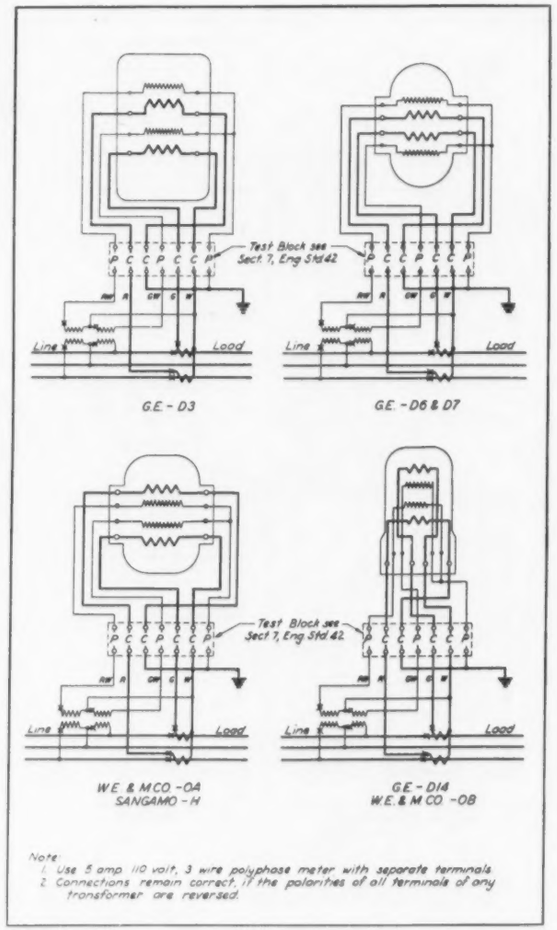

Test Block see Sect. 7, Eng. Std 42
Line
Load
With Current Transformers
With Current and Potential Transformers
3 Phase 3 Wire (2 Element Meter)
With Current Transformers
With Current and Potential Transformers
3 Phase 4 Wire Star (2½ Element Meter)
Note:
1. Use 5 Amp., 110 Volt meters with current and potential transformers
2. Connections remain correct if the polarity of all terminals of any transformer are reversed.

*Connections for Westinghouse type RA demand meters two-element three-phase three-wire, and 2½-element three-phase four-wire.*

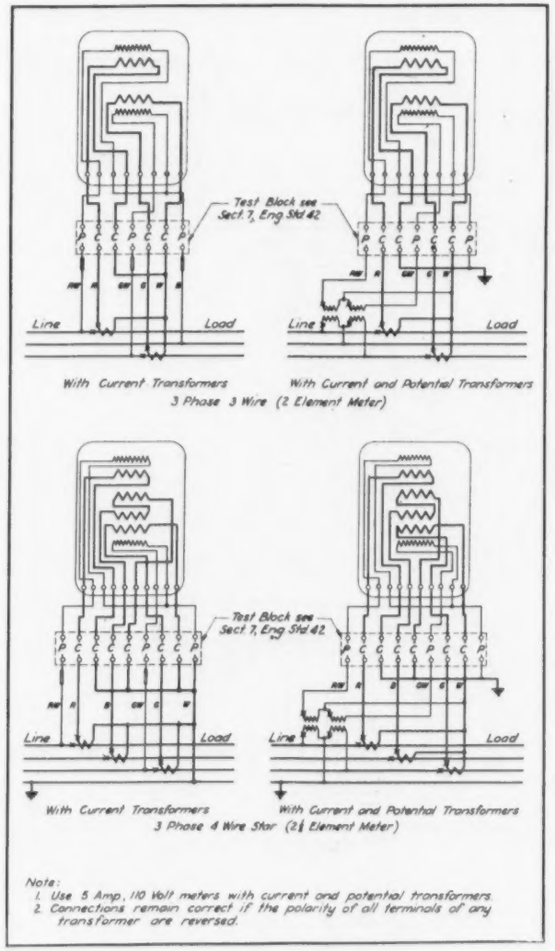

To kw hr Meter
G.E. Co. D6, D7, D14
W.E. & M Co. OA, OB
Sangamo H
See Dwg. 12874
RA See Dwg. 12886
Test Block see Sect. 7, Eng. Std 42
Line
Load
RUN
TEST
Phasing Transformer Test Block see Sect. 10 Eng. Std. 42
G.E. - D14
W.E. & M CO - OB
G.E. - D6 & D7
Phasing Transf. #1
Phasing Transf. #2
P.S.I.
PHASE SEQUENCE INDICATION
CONNECTIONS OF PHASING TRANSFORMERS
Notes:
1. Use 5 amp., 3 wire polyphase meters with separate terminals.
2. Phase sequence indicator should rotate in direction of arrow.

*Connections for metering Rkva.-hr. three-wire three-phase loads with current transformers.*

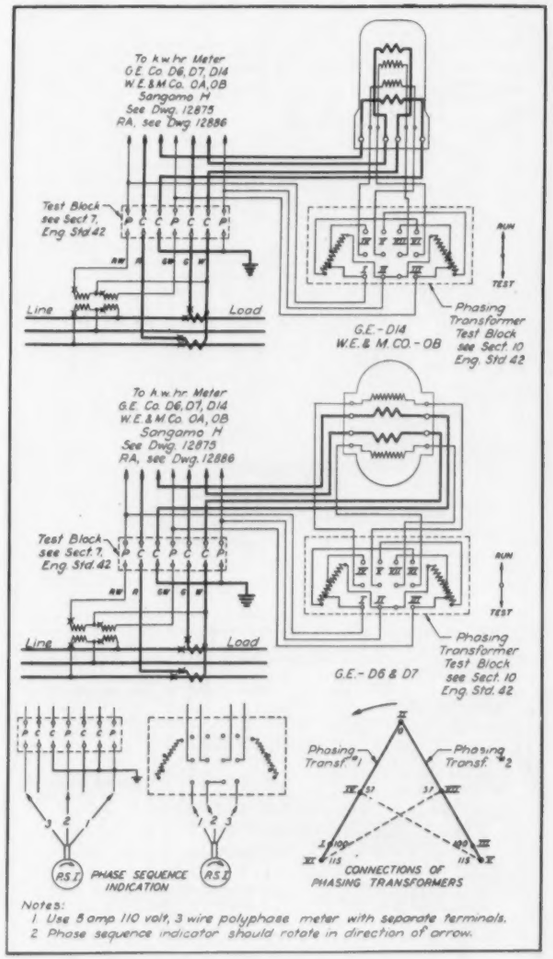
*Fig. 2. Standard drawings as prepared by company D for making installations to meet the requirements of the various power factor rate clauses.*


Test Block see Sect 7, Eng Std 42
Line
Load
G.E. - D3
G.E. - D6 & D7
W.E. & M.CO. - OA
SANGAMO - H
G.E. - D14
W.E. & M CO. - OB
Note:
1. Use 5 amp 110 volt, 3 wire polyphase meter with separate terminals.
2. Connections remain correct, if the polarities of all terminals of any transformer are reversed.

*Connections for metering three-phase three-wire loads with current and potential transformers.*

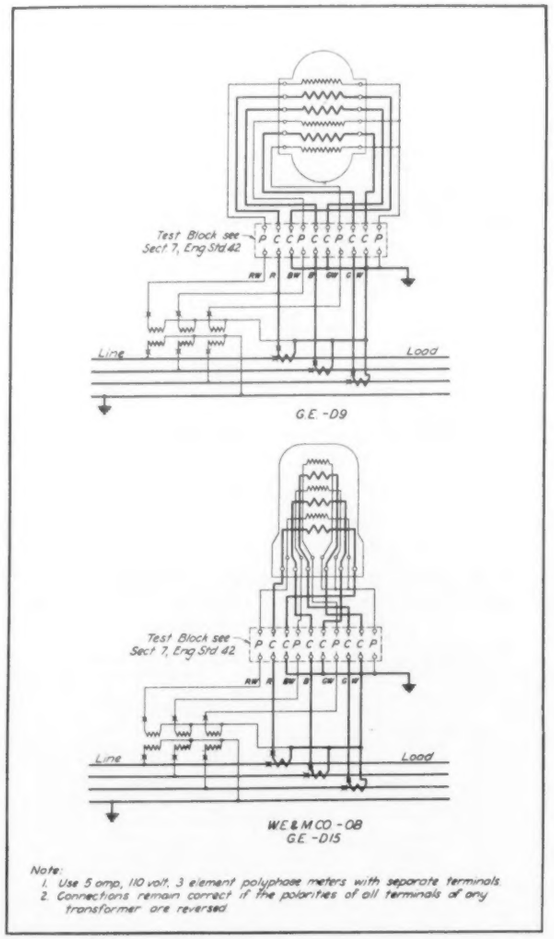

Test Block see Sect 7, Eng Std 42
Line
Load
With Current Transformers
With Current and Potential Transformers
3 Phase 3 Wire (2 Element Meter)
With Current Transformers
With Current and Potential Transformers
3 Phase 4 Wire Star (2½ Element Meter)
Note:
1. Use 5 Amp, 110 Volt meters with current and potential transformers.
2. Connections remain correct if the polarity of all terminals of any transformer are reversed.

*Connections for Westinghouse type RA demand meters two-element three-phase three-wire and 2½-element three-phase four-wire.*

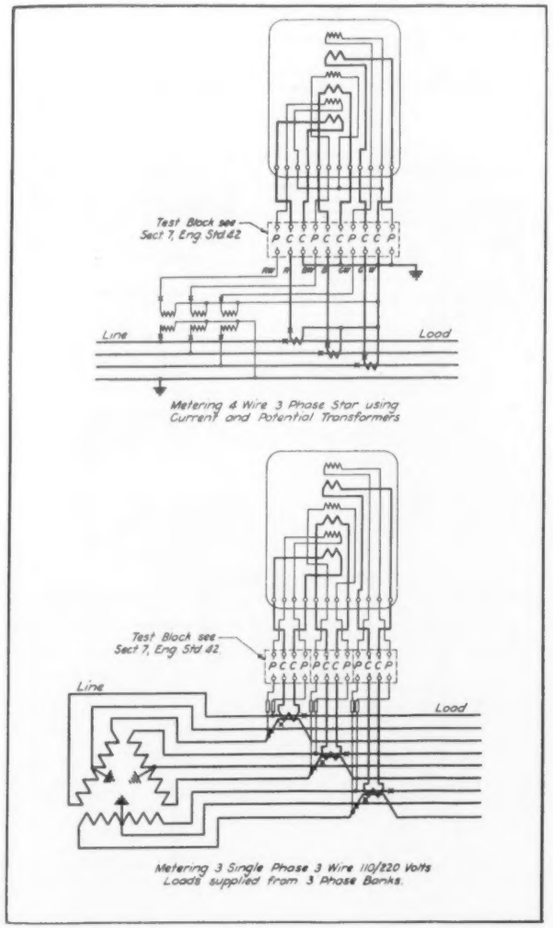

To k.w.hr. Meter
G.E. Co. D6, D7, D14
W.E. & M.Co. OA, OB
Sangamo H
See Dwg. 12875
RA, see Dwg. 12886
Test Block see Sect 7, Eng Std 42
Line
Load
RUN
TEST
G.E. - D14
W.E. & M. CO. - OB
Phasing Transformer Test Block see Sect. 10 Eng. Std 42
G.E. - D6 & D7
Phasing Transf. #1
Phasing Transf. #2
PHASE SEQUENCE INDICATION
CONNECTIONS OF PHASING TRANSFORMERS
Notes:
1. Use 5 amp 110 volt, 3 wire polyphase meter with separate terminals.
2. Phase sequence indicator should rotate in direction of arrow.

*Connections for metering Rkva.-hr. three-wire three-phase loads with current and potential transformers.*

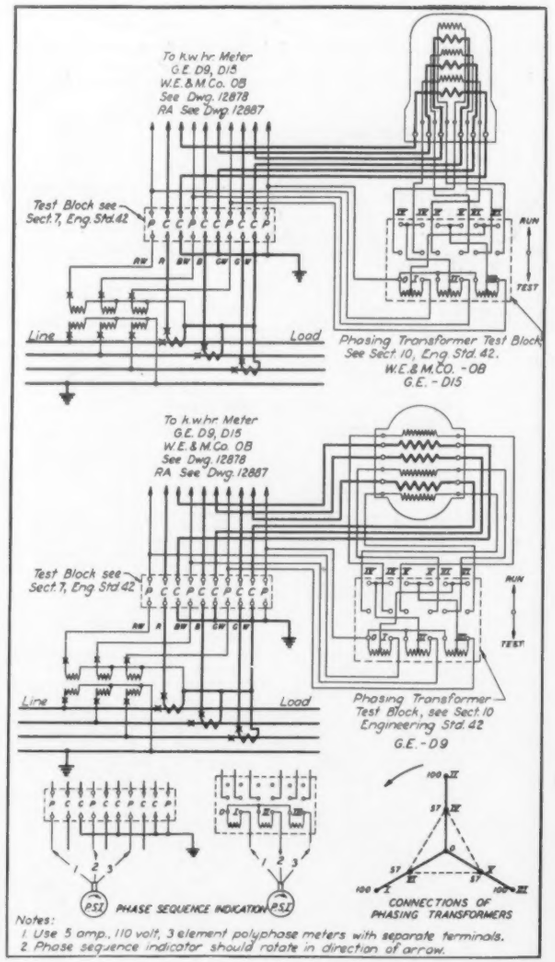
*Fig. 3. Standard drawings as prepared by company D for making installations to meet the requirements of the various power factor rate clauses.*


Test Block see Sect 7, Eng Std 42
P C C P C C P C C P
RW R BW B GW G W
Line
Load
G.E. -D9
Test Block see Sect 7, Eng Std 42
P C C P C C P C C P
Line
Load
W.E. & M CO - OB
G.E. -D15
Note:
1. Use 5 amp, 110 volt, 3 element polyphase meters with separate terminals.
2. Connections remain correct if the polarities of all terminals of any transformer are reversed.

*Connections for metering three-phase four-wire star loads with current and potential transformers using three-element meters.*


Test Block see Sect 7, Eng Std 42
P C C P C C P C C P
RW R BW B GW G W
Line
Load
Metering 4 Wire 3 Phase Star using Current and Potential Transformers
Test Block see Sect 7, Eng Std 42
P C C P C C P C C P
Line
Load
Metering 3 Single Phase 3 Wire 110/220 Volts Loads supplied from 3 Phase Banks.

*Connections for Westinghouse three-element type RA watt-hour demand meters.*


To k.w.hr Meter
G.E. D9, D15
W.E. & M Co. OB
See Dwg. 12878
RA See Dwg. 12887
Test Block see Sect 7, Eng Std 42
P C C P C C P C C P
RW R BW B GW G W
RUN
TEST
Line
Load
Phasing Transformer Test Block See Sect 10, Eng Std 42.
W.E. & M.CO. - OB
G.E. - D15
To k.w.hr Meter
G.E. D9, D15
W.E. & M Co. OB
See Dwg. 12878
RA See Dwg. 12887
Test Block see Sect 7, Eng Std 42
Line
Load
Phasing Transformer Test Block, see Sect 10 Engineering Std. 42
G.E. - D9
1 2 3
PSI
PHASE SEQUENCE INDICATION
PSI
CONNECTIONS OF PHASING TRANSFORMERS
Notes:
1. Use 5 amp., 110 volt, 3 element polyphase meters with separate terminals.
2. Phase sequence indicator should rotate in direction of arrow.

*Connections for metering Rkva.-hr. four-wire three-phase loads with current and potential transformers.*

ported that they were installed by their meter department or under its direct supervision.

### Testing Instructions on Rkva. Meters

*Testing With Phase Sequence Indicator—*

Company D has prepared a complete set of instructions covering the procedure for testing Rkva. installations to determine the accuracy of connections. These include: (1) three-wire, three-phase, two-element meter with current and potential transformers; (2) four-wire, three-phase, three-element meter with current and potential transformers; (3) four-wire, three-phase 2½-element meter with current and potential transformers using phasing transformers; (4) four-wire, three-phase 2½-element meter with current and potential transformers using a reactiformer. Its testing instructions covering three-wire, three-phase, two-element meters with current and potential transformers are reprinted as a matter of information:

#### Procedure For Testing Rkva. Installations to Determine Accuracy of Connection

*Three-wire, Three-phase, Two-element Meter With Current and Potential Transformers*

(1) First make sure that the watthour meter installation is connected up as shown on drawings No. 12874 or 12875, with test block terminal P2 in the common potential circuit.

(2) To determine correctness of phase sequence at test block.
- (a) Connect phase sequence indicator (P.S.I.) to points P1, P2 and P3 as follows:
  Connect P.S.I. terminal No. 1 to test block at P1.
  Connect P.S.I. terminal No. 2 to test block at P2.
  Connect P.S.I. terminal No. 3 to test block at P3.
- (b) If rotation is as shown by arrow on P.S.I., phase sequence is O. K.
- (c) If rotation is opposite to arrow on P.S.I., phase sequence is wrong. To correct phase sequence, proceed as follows: (paragraphs d and e.)
- (d) Interchange wires from potential transformer (between potential transformer and test block) to test block terminals P1 and P3, leaving common wire on P2.
- (e) Interchange wires C1 and C3, from current transformers to test block terminals (between current transformer and test block), leaving common terminals as they are.
- (f) After making changes 2(d) and 2(e), repeat test (2). Rotation should be as shown in 2(b).

(3) Additional check on phase sequence at test block.
- (a) With correct phase sequence at test block and lagging power factor, terminals P1 and C1 (left hand) go to slow or backward running element of meter; terminals P3 and C3 (right hand) go to fast forward running element of meter.

(4) Wire reactiformer and Rkva. meter as per drawings No. 12942 and 12943.

(5) Checking phase sequence at reactiformer.
- (a) Contact phase sequence indicator to reactiformer terminals I, II and III as follows:
  Connect P.S.I. terminal No. 1 to terminal I.
  Connect P.S.I. terminal No. 2 to terminal II.
  Connect P.S.I. terminal No. 3 to terminal III.
- (b) Phase sequence indicator rotation should be as shown on arrow.
- (c) If rotation is opposite to arrow, check connection and correct same.
- (d) Connect P.S.I. as follows:
  Connect P.S.I. terminal No. 1 to terminal V.
  Connect P.S.I. terminal No. 2 to terminal VI.
  Connect P.S.I. terminal No. 3 to terminal IV.
  Rotation should be as shown on arrow.

(6) Check of Rkva. meter on kw.-hr. connection.
- (a) Put reactiformer switch in test position.
- (b) Checks watts shown by watthour meter against watts shown by Rkva. meter.
- (c) Watts shown by watthour meter and Rkva. meter should be equal.
- (d) If watts of watthour meter and Rkva. meter do not check, compare connection with drawing and correct.
- (e) If watts of watthour meter and Rkva. meter still do not check, test both meters and, if necessary, adjust.

(7) Comparison of power factor by two methods.
- (a) Get ratio between registration of P1 C1 element of watthour meter and P3 C3 element (or between slow or backward and fast forward running elements) and obtain power factor from chart on drawing No. 12985.
- (b) With reactiformer in running position, check watts from watthour meter and Rkva. from Rkva. meter and determine power factor from chart on drawing No. 12984.
- (c) Power factor obtained by method in test 7 (a) should check with power factor obtained from test 7 (b).

Note: Due allowance should be made for variation in these tests and several tests should be made alternating between methods 7 (a) and 7 (b) to get average conditions.

- (d) If all tests previous to tests 7 (a) and 7 (b) show correct conditions and power factors obtained in 7 (c) do not check within reasonable limits, check internal connections of reactiformer. These connections should be as shown by roman numerals on reactiformer and vector diagram of drawings No. 12942 and 12943, also as shown by diagram of connections in reactiformer cover. (Pay no attention to advice about interchanging of connections of leads A-B and C-B in cover).

Note: In connection with determination of power factor from ratios according to drawing No. 12984 and 12985, it is simpler to take, instead of the ratios of the calculated watts or Rkva., the reciprocal of the corresponding time per revolution.

*Testing With Phase Shifter—*

Company B reports that they test all Rkva. installations with a phase shifter. Special switches are used to change the Rkva. meter to a watthour meter during test. They connect a three-phase shifter in the potential shifter which supplies both the watthour meter and the Rkva. meter. The phase shifter is first set so that the Rkva. meter stops. The watthour meter is then timed with a stop watch. The phase shifter is then moved back 90 degrees, and a check made to see that the watthour meter stops. The Rkva. meter should show the same speed that the watthour meter showed on the previous test.

This method of testing the installation is very interesting in that the voltage vectors on the elements of both the watthour, and Rkva. meter are simultaneously changed and the test proved the connections as well as the taps on the phasing transformers.

*Use of Portable Phase Indicator—*

Two of the companies reporting stated that while they had not used a portable phase indicator in Rkva. meter work, they were interested in seeing such an instrument tried out on field tests.

### Reading of Rkva. Meters And Computing of Monthly Average Power Factor

*Reading—*

One company reported that all Rkva. meters are read by the meter test department.

Another company reported that its reactive meters were badly scattered, making it impractical to read these meters by the meter test department. In all cases, however, readings are taken by carefully selected men, as the demand meters must be accurately read; charts must also be changed or the pointers read and reset. The Rkva. meter is read simultaneously with the watthour meter, so that the average power factor can be correctly computed.

*Computing of Power Factor*

One company reported that the monthly average power factors on consumers' loads are computed by the meter test department.

Another company reported that its billing department computes all monthly power factors from specially prepared charts.

The power factor rate clauses established by companies B, C and D all necessitate some form of chart or curve in computing the monthly average power factor from the ratio of the Rkva. to the watthour meter readings.

Company D has issued, through its commercial department, a special chart for use in computing the "equivalent

multiplier" to apply to the billing under its various schedules. Several forms of charts and curves were considered before this one was adopted. The advantages claimed for its chart, as shown in Fig. 4, are simplicity in billing and the minimizing of personal errors.

Subject:— Power Factor Chart
For use in billing under the Power Factor clause of Schedules P-1, P-5, P-21, and 4-E

To determine power factor:

1. Divide reactive kilovolt-ampere-hours by kilowatt-hours. (Reactive kv-a-hrs and kw hrs determined from meter readings each month) Carry quotient to four decimal places.
2. Locate in column #1 the block in which quotient falls.
3. Corresponding Power Factor is shown on the same line in column #2.
4. The premium or penalty percentage (discount or increase) is shown on the same line in column #3.
5. Equivalent multiplier is shown in column #4.

| #1 Blocks (Reactive kv-a-hrs divided by kw hrs) | #2 Power Factor | #3 Discount or Penalty | #4 Equivalent Multiplier |
|---|---|---|---|
| From 0.0000 to .1004 | 100% | 5.0% | .950 |
| " .1005 " .1752 | 99 | 4.8 | .952 |
| " .1753 " .2279 | 98 | 4.6 | .954 |
| " .2280 " .2718 | 97 | 4.4 | .956 |
| " .2719 " .3105 | 96 | 4.2 | .958 |
| " .3106 " .3460 | 95 | 4.0 | .960 |
| " .3461 " .3792 | 94 | 3.8 | .962 |
| " .3793 " .4108 | 93 | 3.6 | .964 |
| " .4109 " .4411 | 92 | 3.4 | .966 |
| " .4412 " .4702 | 91 | 3.2 | .968 |
| " .4703 " .4984 | 90 | 3.0 | .970 |
| " .4985 " .5261 | 89 | 2.7 | .973 |
| " .5262 " .5532 | 88 | 2.4 | .976 |
| " .5533 " .5801 | 87 | 2.1 | .979 |
| " .5802 " .6066 | 86 | 1.8 | .982 |
| " .6067 " .6330 | 85 | 1.5 | .985 |
| " .6331 " .6590 | 84 | 1.2 | .988 |
| " .6591 " .6849 | 83 | .9 | .991 |
| " .6850 " .7111 | 82 | .6 | .994 |
| " .7112 " .7371 | 81 | .3 | .997 |
| " .7372 " 1.1848 | 80 to 65 | -- | 1.000 |
| " 1.1849 " 1.2167 | 64 | .5 | 1.005 |
| " 1.2168 " 1.2489 | 63 | 1.0 | 1.010 |
| " 1.2490 " 1.2822 | 62 | 1.5 | 1.015 |
| " 1.2823 " 1.3162 | 61 | 2.0 | 1.020 |
| " 1.3163 " 1.3511 | 60 | 2.5 | 1.025 |
| " 1.3512 " 1.3865 | 59 | 3.0 | 1.030 |
| " 1.3866 " 1.4229 | 58 | 3.5 | 1.035 |
| " 1.4230 " 1.4605 | 57 | 4.0 | 1.040 |
| " 1.4606 " 1.4988 | 56 | 4.5 | 1.045 |
| " 1.4989 and over | 55 | 5. | 1.050 |

Example

Registration of reactive kilo-volt-ampere meter 21,213
Registration of kilowatt watthour meter 40,420
Amount of bill in accordance with Schedule P-1,(before power factor adjustment) $677.59
21,213 R.K.V.A. divided by 40,420 KWH = .5248
.5248 falls in the block "4985 to 5261" therefore the power factor is 89%
89% power factor entitles consumer to a discount of 2.7%
Multiplier for 2.7% is .973
$677.59 x .973 = $659.30 = amount of bill.

*Fig. 4. Sheet of instructions to accompany special chart issued by company D for use in computing the "equivalent multiplier" to apply to the billing under its various schedules.*

## Special Tests and Investigations

*Study of Consumers' Power Factor—*

One company reported on a study of some 96 representative loads on its system, which was used as a basis in establishing a rate clause on power factor. The survey was made, using portable equipment consisting essentially of two recording demand watthour meters mounted in a box. One of these meters was connected with phasing transformers, so as to measure the Rkva.-hours as well as the Rkva. demand; the other meter was connected to measure the kilowatt-hours and kilowatt demand.

*Reactive Metering of Single Phase Installation—*

One company reported on the metering of a special installation where the load consisted of some 1,360 hp. in three-phase 440-volt motor load, together with a large single-phase electric furnace. Owing to the single-phase load being taken from a separate transformer, phasing transformers could not be used to get the desired lagging voltage on the Rkva. meter. The Rkva. metering apparatus, as finally selected for the single-phase measurement, consists of special capacitors with resistance units connected in parallel. This unit was placed in series with the potential circuit of the single-phase Rkva. meter. The manufacturer of the phasing device suggests that there is a possibility of temperature variations with condensers and recommends that a periodic check be made on the installation at least every six months. This installation has been in service for approximately six months and has proved very satisfactory.

## Test of Accuracy of Rkva. Meter Under Unbalanced Conditions of Load and Voltage

The test was made using three rotating standards, three ammeters, three current transformers, three voltmeters, a three-phase watthour meter, a phasing transformer, and a motor generator set for load and resistances to unbalance the line voltage. Fig. 5 shows the diagram of connections used. The secondaries of the current transformers were connected, closed delta, and connected to the rotating standards and ammeters, which were connected in star. It can be shown vectorially that instruments connected in this manner measure just three times the current in the motor windings; by this method, therefore, it was possible to measure voltage,

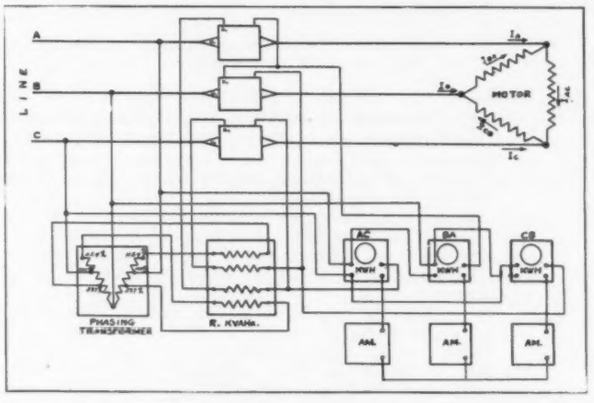



*Fig. 5. Diagram of connections used in test of accuracy of Rkva. meter under unbalanced conditions of load and voltage.*

current and watts input to each phase of the motor. This was considered necessary in order to get an accurate measurement of power factor with extreme unbalanced load and voltage.

Readings of voltmeters and ammeters were taken while the rotating standards and stop watch were run, during an interval of time corresponding to a counted number of revolutions of the Rkva. meter. It was then possible to calculate the watts and volt-amperes in each phase, also the Rkva. shown by the Rkva. meter.

The sum of the watts in the three phases, when divided by the sum of the volt-amperes in the three phases, was considered to be the true power factor. This power factor was then compared to the power factor indicated by the Rkva. meter.

The unbalance was obtained by inserting resistance into one or two of the lines ahead of all the instruments. Inserting resistance in two wires was considered to approximate the unbalanced voltage which would be produced by a heavy single-phase load connected to two of the phase wires. A resistance inserted in one wire would cause a voltage unbalance similar to that caused by a badly unbalanced four-wire, three-phase primary.

A number of checks were made with voltages unbalanced, both by the above methods and with the motor running on light load so it would have a low power factor. Checks were also made with a single-phase load added to the three-phase motor load.

As a check on the results obtained, vector diagrams were drawn to scale showing all the voltages and currents involved in the test. Angles between voltages and currents were obtained from power factors computed from the test data. The diagram was finally checked to see if the voltage

and current triangles would close. An example of these diagrams is shown in Fig. 6.

The lettering of the figures illustrates the method of its construction. The lettering of Fig. 6 corresponds to that of Fig. 5 and is as follows:

EBA—Voltage, wire B to wire A
ECB—Voltage, wire C to wire B
EAC—Voltage, wire A to wire C
IBA—Current in motor winding flowing from wire B to wire A
ICB—Current in motor winding flowing from wire C to wire B
IAC—Current in motor winding flowing from wire A to wire C
IA —Current in wire A
IB —Current in wire B
IC —Current in wire C
EAB 90—57.7 per cent of vector EBA reversed, plus 115.4 per cent of vector CB.
ECB 90—57.7 per cent of vector ECB, plus 115.4 per cent of vector EBA reversed.
EAB —EBA reversed.

The following operations are performed vectorially in the construction of Fig. 6:

IA=IAC—IBA
IB=IBA—ICB
IC=ICB—IAC
As a check IA—IC=—IB

If the last operation above were not true it would show an error in the test or calculatinos.

The tests lead to the following conclusions, which are borne out by the vectorial analysis:

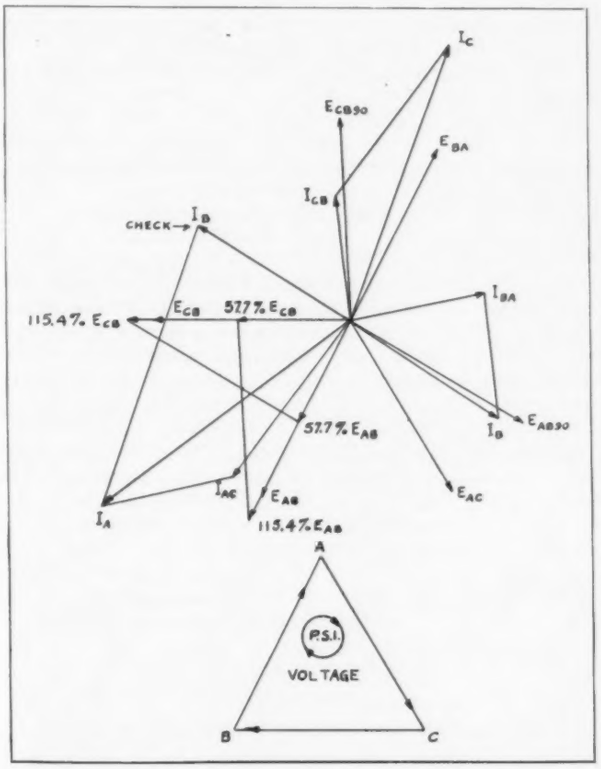



*Fig. 6. Sample of vector diagram drawn to scale, showing all the voltages and currents involved in the test.*

If the voltages remain balanced, unbalanced currents will cause no error in an Rkva. meter of this type.

A voltage unbalance of 8 per cent, caused by badly unbalanced four-wire, three-phase primary, could cause a 10.7 per cent error in the power factor calculated from the Rkva. meter registration, using 50 per cent power factor load.

A voltage unbalance of 3 per cent, caused by heavy single-phase secondary load, would cause about 3 per cent error in the power factor, calculated from Rkva. meter registration.

In every case the error is caused mainly by error in voltage output of the phasing transformer and not by the phase position error. Therefore a fair idea of the error to be expected can be gained by a voltmeter comparison of the input to the output voltage of the phasing transformer.

In any case, the error can be quite accurately checked by vector analysis of ammeter measurements of the currents in the three line wires and phase-to-phase voltage measurements.

Under average voltage conditions the Rkva. meter is within commercial accuracy.

### Neon Signs

Neon signs, increasing in popularity within the last few years, have recently caused some concern as to their effect on power factor on the systems serving them. These neon signs, which operate at high voltages, are usually supplied from the secondary of special high-voltage transformers having high reactance, and consequently the sign installations are operated at 40 to 50 per cent power factor.

One company reported having made a survey of neon sign lighting in a few selected areas in its metropolitan districts, the object of the survey being to determine the loads on neon sign lighting in comparison with the amounts of other loads in the same area and to determine the effect of these loads on the power factor of the feeders. In the four blocks surveyed, each block representing one side of the street only, neon signs were found, ranging from 15/100 kw. to 35 kw.; twenty signs were found in block No. 1, eight in block No. 2, six in block No. 3. From the survey it was found that the total kva. required for neon signs is only a small proportion of the total kva. and had very little effect on the power factor of the feeders. The power factor of the feeders supplying some of these sections was known to be 85 per cent or better, when the sign lighting was on in the evening. The segregation of loads in the four locations was as follows:

| | D.C. Motors Hp. | A.C. Motors Hp. | Appliances Kw. | Lighting Kw. | Neon Signs Kw. |
|---|---|---|---|---|---|
| Block No. 1 | 151 | 156 | 185 | 558 | 67 |
| Block No. 2 | 163 | 38 | 133 | 157 | 13 |
| Block No. 3 | .... | 4 | 36 | 32 | 4 |
| Block No. 4 | * | * | 34 | 49 | 3 |

* Not surveyed.

## *Special Tests and Investigations**

### *Methods of Determining Ground Resistance*[2]

*Recently considerable interest has been displayed in the subject of ground resistance testing, brought about by the necessity of adequate grounding for the satisfactory operation and protection of both power and communication systems. In this paper the fundamental theory and the practical methods of making ground measurements are briefly discussed. The types of apparatus used in making measurements are discussed, including both assembled apparatus and some of the compact portable instruments now available on the market, designed for this particular purpose. A method of measuring station grounds wherein the resistances may be of a very low value is discussed.*

* Report of subcommittee on special tests and investigations, meter committee, Engineering Section. O. A. Knopp, chairman.

[2] Prepared by L. C. Edwards for the subcommittee on special tests and investigations, meter committee, Engineering Section.

ALL methods of determining the resistance of a ground-to-earth connection are fundamentally based on an application of Ohms law to the potential across the ground and the current through the ground. In all methods it is necessary to complete the ground circuit by the use of at least one auxiliary ground, although in those methods where accuracy is desired, two auxiliary grounds are necessary.

An alternating current is preferable to direct current for making measurements upon ground connections. The alternating current is free from the effects of polarization; it is free from the effect of stray d.c. ground currents, and it can be rendered free of stray a.c. ground currents by the use of a frequency different from that of the ground current.

The various methods of measuring ground resistance can be divided into three general classes, as follows:

Three-point method
Fall-of-potential method
Kohlrausch-bridge method.

In the three-point method, two auxiliary current carrying grounds are necessary. Three sets of resistance values are measured for the three possible series combinations, comprising the ground under test and the two auxiliaries; then, by simultaneous equations, the value of the ground under test is computed.

In the fall-of-potential method, one auxiliary current ground and an auxiliary potential ground is necessary. The resistance of the ground under test is computed by an application of Ohms law to the potential drop across the ground under test, as measured by the auxiliary potential ground, and the current supplied through the ground circuit of the two current carrying grounds.

The Kohlrausch bridge method utilizes the same auxiliary ground arrangement as the fall-of-potential method, through a different type of measuring circuit arrangement. In this method the resistance of the ground under test is computed from two measurements, one indicating the sum of two restances, and the other indicating their ratio.

An auxiliary ground may be a metallic rod driven into earth especially for the purpose, or it may be any piece of metal buried in the earth, such as a guy wire or a steel pole. The only condition imposed upon the auxiliary current grounds is that they be of sufficiently low resistance to give good current readings, and sufficiently far apart from each other and the ground under test as not to interfere with the results. The auxiliary potential ground as used in the fall-of-potential and the Kohlrausch bridge methods must, in addition, be free and isolated from all other ground connections.

The distance from the auxiliary ground to the ground under test is governed by the degree of accuracy required. For highest accuracy this distance should be 100 ft. for the current carrying grounds. However, for all practical purposes, good results can be obtained with half this separation. In the fall-of-potential and Kohlrausch bridge methods, the auxiliary potential ground is placed midway between the auxiliary current-carrying ground and the ground under test.

A brief discussion of the instruments used and the test procedure for the three general methods follows:

### Three-Point Method

*Voltmeter-Ammeter Tests—*

Refer to Fig. 1. This test involves the use of the ground under test, designated (X), and two auxiliary current carrying grounds (A) and (B). The resistances of the three grounds are determined by measuring two at a time in series, the series resistances being determined from the potential and current values, (E) and (I) respectively.

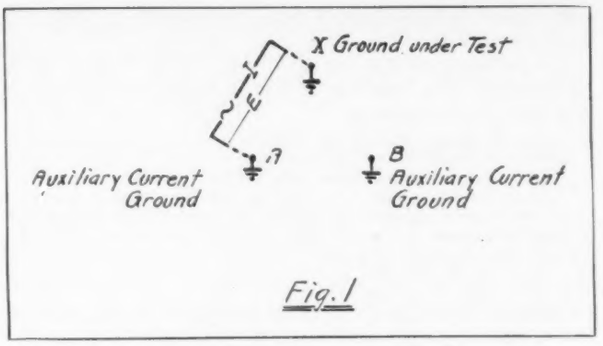



*Fig. 1. Voltmeter-ammeter test, three-point method.*

| | |
|---|---|
| Let the series resistance | $X + A = R_1$ |
| Let the series resistance | $X + B = R_2$ |
| Let the series resistance | $A + B = R_3$ |
| By addition | $2X + 2A + 2B = R_1 + R_2 + R_3$ |
| | $2A + 2B = 2R_3$ |
| subtracting $2(A + B = R_3)$, then | $2X = R_1 + R_2 - R_3$ |
| simplifying | $X = \frac{R_1 + R_2 - R_3}{2}$ |

The test circuit must be isolated from the line and other possible ground connections by means of a transformer when the supply is taken from a distribution line.

Stray d.c. currents in the earth have no effect, but a.c. ground currents of the same frequency as the test current will introduce an error. The Bureau of Standard states that this method is very reliable, in fact the chief advantage lies in the dependability of the results. The disadvantages are in the quantity of instruments and preparation necessary, as well as the amount of computation involved.

*Wheatstone Bridge Test—*

Refer to Fig. 2. The method of procedure is much the same as for the voltmeter-ammeter test. The resistances of the three grounds are measured two at a time in series, and the resistance of the one under test computed from the simultaneous equations.

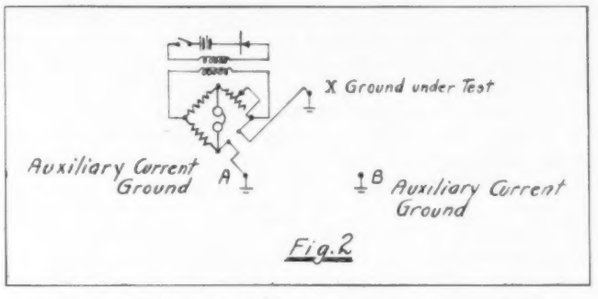



*Fig. 2. Wheatstone bridge test, three-point method.*

The apparatus consists of a Wheatstone bridge, dry battery, buzzer and transformer, to supply a rapidly pulsating current. A telephone receiver replaces the galvanometer of the bridge and is used to determine the point of balance by adjusting for minimum sound.

The results obtained are comparable with those of the voltmeter-ammeter tests; the results of comparative tests show them to check within a few per cent.

The outfit is portable, does not depend for measuring current upon the proximity of a low voltage a.c. circuit, and the number of computations is somewhat less than those of the voltmeter-ammeter tests.

The main disadvantage is that it is difficult to obtain a definite point of balance; this may be due to either of several causes, as follows: stray earth currents, especially those containing some audible d.c. commutation, impossibility to compensate for capacity and inductance when very long test leads are used, or finally, the difficulty of determining the occurrence of minimum sound in the telephone, especially when there is extraneous noise present.

A recent development in a portable compact instrument suitable for operation on the three-point method is called the Ground-O-Meter.

### Fall-of-Potential Method

*Voltmeter-Ammeter Test—*

This method is fundamentally as shown in Fig. 3. A current (I) is supplied to the series circuit comprising the ground under test (X), and an auxiliary current ground (A). The potential drop (E) across the ground (X) is the value measured between this ground and the auxiliary potential ground (P). The resistance (X) is then simply computed from the relation E/I.

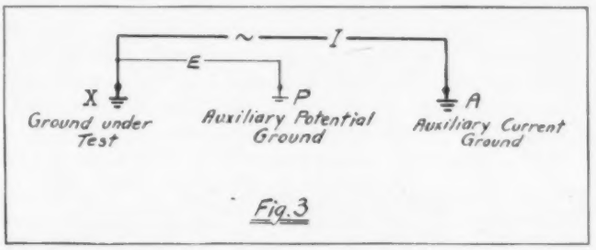



*Fig. 3. Voltmeter-ammeter test, fall-of-potential method.*

This method of testing is superior to the three-point method in that it requires but one set of readings and one computation. However, an appreciable error is introduced if any appreciable current is drawn through the potential circuit by the use of a low resistance voltmeter. In most cases an a.c. voltmeter is relatively low in resistance as compared with a d.c. instrument.

Compact and portable instruments have recently been developed which operate on the fall of potential principle. Included among these are the Megger and the ground-ohmer.

The Megger consists essentially of a d.c. hand-driven permanent magnet generator, a current reverser, and a d.c. ohmmeter somewhat similar to a D'Arsonval galvanometer, The d.c. current is reversed for supply to the ground circuit and then converted into direct current again for actuation of the ohmmeter. The resistance of the potential circuit is very high so that but a small current is drawn through the auxiliary potential ground.

The chief advantage claimed is the sensitiveness and accuracy of the d.c. indicating ohmmeter.

The ground-ohmer consists of an a.c. hand-driven permanent magnet generator, a slide wire adjustment for balance, and a dynamometer type galvanometer. At normal cranking speed the frequency is 35 cycles. The point of balance is obtained by turning the slide wire resistance dial until the galvanometer pointer indicates a zero deflection; the resistance is then read off a scale beneath a pointer on the slide wire knob. The chief advantages claimed for this instrument are ruggedness, and non-effect of auxiliary ground resistances on the results. When the circuit is balanced, there is no current in the potential circuit.

### Kohlrausch Bridge Method

*Kohlrausch Bridge Test—*

This method of test utilizes the same auxiliary ground arrangement as the fall-of-potential method, i.e., a current and a potential ground. Two sets of measurements are made and from these the resistance of the ground under test is computed. The circuit arrangements for the two tests are shown in (I) and (II), Fig. 4.

The resistance of (X) and (A) in series is first determined by a Wheatstone bridge arrangement as shown in (I), Fig. 4.

The result $X + A = R$ is obtained.

The ratio of the two resistances is next determined by a Kohlrausch bridge arrangement as shown in (II), Fig. 4. When the two arms ($r_1$ and $r_2$) are adjusted for minimum sound in the telephone receiver, the following relationship obtains:

$$\frac{A}{X} = \frac{r_2}{r_1}, \text{ or } A = (X)\frac{r_2}{r_1}$$

substituting this value of (A) in $X + A = R$, this is obtained

$$X + (X)\frac{r_2}{r_1} = R$$

simplifying $$X\left(1 + \frac{r_2}{r_1}\right) = R$$

then $$X = \frac{R}{1 + \left(\frac{r_2}{r_1}\right)}$$

A recent development of the Ground-O-Meter operates on this principle. The instrument is compact and self-contained; it consists essentially of a battery, high frequency buzzer, telephone-receiver detector, and the necessary bridge arms. The change from the Wheatstone bridge arrangement to the Kohlrausch scheme is accomplished by merely throwing a switch.

The makers claim great improvement in sharpness of balance by a specially designed buzzer and polarized telephone receiver.

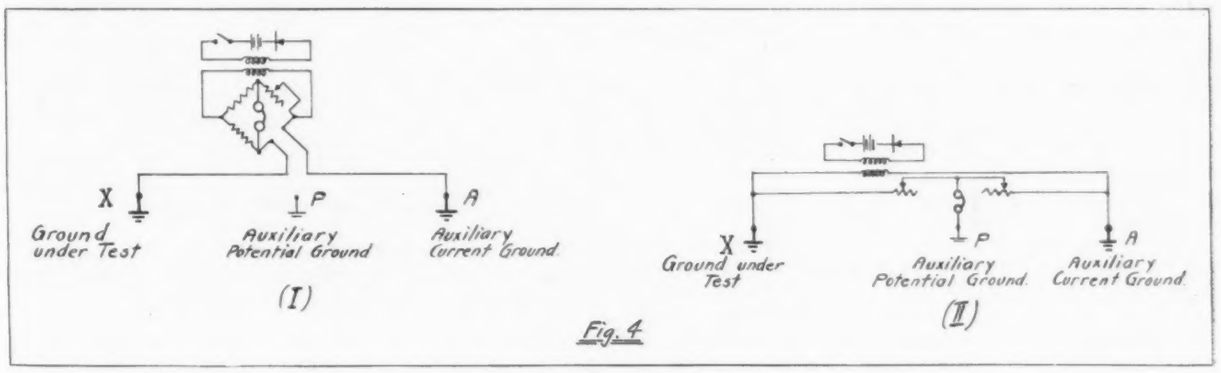



*Fig. 4. Circuit arrangements for two tests, Kohlrausch bridge method.*

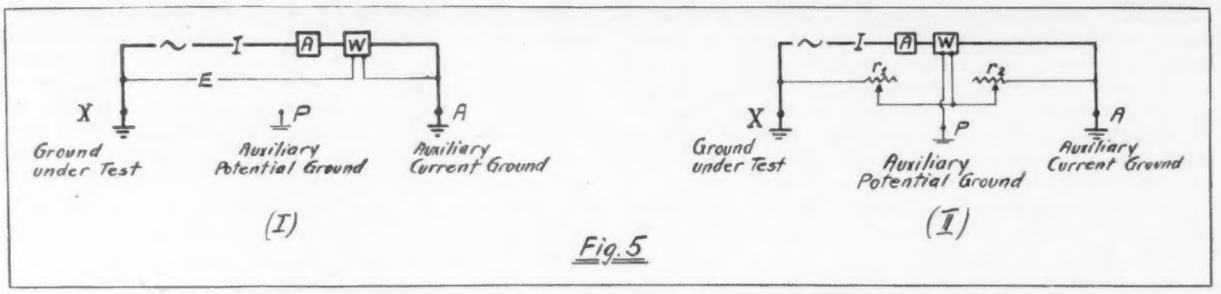



Fig. 5

*Fig. 5. Circuit arrangements, special adaptation, Kohlrausch bridge method.*

*Special Adaptation—*

A special adaptation of the Kohlrausch bridge method has been used by the Pacific Gas and Electric Company in determining the resistances of station grounds. These resistances are very low; they may in some cases be of the order of a few thousandths of an ohm.

The arrangement is essentially the same as that previously described, the chief difference being in the instruments and current used.

For these tests it was necessary to establish large low resistance auxiliary current grounds.

The circuit arrangements are as shown in (I) and (II), Fig. 5.

A 30-cycle current was supplied by means of a small motor driven generator. The 30-cycle current was chosen so as to render the measurements practically free of interference from 60-cycle ground currents. The current supplied to the series circuit of the two grounds, (X) and (A), was measured by means of an ammeter.

A wattmeter was used, first in the measurement of the series resistance, and secondly as a dynamometer balance indicator; for this purpose all external resistance of the potential circuit was shunted out.

Referring to (I), Fig. 5, the sum of the two resistances X + A was computed from the current and wattage values,

$$\text{Then } X + A = R = \frac{W}{I^2}$$

Then utilizing the Kohlrausch arrangement in II, Fig. 5, the balance of the two arms ($r_1$) and ($r_2$) was determined for zero deflection of the wattmeter, then

$$\frac{A}{X} = \frac{r_2}{r_1}$$

and

$$A = (X)\frac{r^2}{r_1}$$

substituting this value of (A) in $X + A = R = \frac{W}{I^2}$

is obtained

$$X = \frac{R}{1 + \left(\frac{r_2}{r_1}\right)} \qquad \text{or} \qquad X = \frac{W}{I^2\left(1 + \frac{r^2}{r_1}\right)}$$

This method has been used many times with entire satisfaction. Check tests with different values of current ranging from 1 to 5 amperes, and bridge arms ranging from 1 to 100 ohms have given very consistent results. It is felt that by this means the value of low resistance grounds can be determined with a fair degree of accuracy.

## *Calibration of High Voltage Potential Transformers Using a Standard of Different Voltage Rating*[2]

*Methods are described whereby potential transformers may be calibrated, either in the laboratory or in the field, using a standard of different voltage rating. The comparison of the secondary voltages is made with aid of a potentiometer and "null" detector. The test transformer can be calibrated at a voltage less than normal if the standard has an insufficiently high voltage rating.*

IT is not unusual to desire accuracy tests on transformers operating on high voltages, for which a standardized potential transformer of the same voltage rating is not available.

In general, any high voltage transformer might be calibrated against a differently rated voltage transformer, as standard, by the laboratory method to be outlined.

Errors may be relied upon not to exceed 0.2 per cent in ratio and 10 minutes in phase angle. The secondary burden of the transformer under test is either zero or normal, but must be reduced proportionately to the square of the ratio of the primary test voltage to its normal operating voltage, if the test voltage is lower than normal.

Characteristics of the test transformer for other than the test burden can be either calculated or derived from inspection of the manufacturers' curves for such a type of transformer.

Further description is most easily followed by considering an actual case, as represented by the wiring diagram. (Fig. 1.)

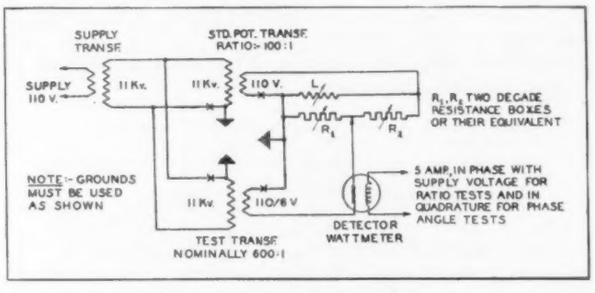



*Fig. 1. Wiring diagram for calibration of transformer, using a differently rated voltage transformer.*

In this case a 66,000-volt transformer is to be calibrated, using a 11,000-volt supply and a 11,000-volt standard potential transformer. The secondary burden on the test trans-

[2] Prepared by N. M. Albert for the subcommittee on special tests and investigations, meter committee, Engineering Section.

former is shown as zero and accordingly, even for partial normal excitation, the secondary phase angle is leading.

The secondary on the standard potential is burdened by two dial decade resistance boxes of approximately 10,000 ohms each. The greater the unity power factor burden on a potential transformer, the more the secondary phase angle is lagging; hence, sufficient inductive burden must also be placed across the secondary of the standard to bring its phase angle as much leading as is the secondary of the test transformer. The ratio of $R_1$ to $R_2$ is varied, preferably by holding one fixed at, say, 10,000 ohms and varying the other, so that the following relation is fulfilled:

$$\frac{\text{Sec. volts of standard potential transformer}}{\text{Sec. volts of test potential transformer}} = \frac{R_1 + R_2}{R_1}$$

This condition is complied with when the detector wattmeter reads zero, as the normal rated current of the detector wattmeter is changed from "in phase with" or "in quadrature with" the line supply voltage.

As just stated, the secondary of the test and that of the standard transformer will be in phase.

To determine the absolute ratio and phase angle error of the test transformer, it is now necessary to calibrate the standard potential transformer by some separate method, holding the magnitude of L, $R_1$ and $R_2$ as determined in the prior test. Its phase angle, accordingly, is then also the phase angle of the test transformer at zero burden. It is desirable, almost necessary, to have as a standard potential transformer, one having a calibrating winding, such as the Knopp multirange potential transformer, which has the valuable feature of being easily calibrated within itself, i.e., without reference to any other standard, with any value of secondary burden and at any percentage of normal rated potential.

An actual test on a 600 to 1 ratio potential transformer showed a decrease of approximately 0.07 per cent in secondary output voltage at zero burden, as primary voltage decreased from 100 per cent to 20 per cent normal value. This last statement justifies the calibration of a test transformer at less than normal excitation, particularly as the results, even though not absolutely accurate, are more valuable than the indefinite guess necessary with no test at all.

The above tests, though most readily made in the laboratory, can be made with difficulty in the field. For field tests, however, it should be sufficient to make a ratio test alone. The difficulties are then decreased, for the variable inductance is not required, neither is a three-phase supply from which to obtain current for the detector wattmeter. Since, in a field test, the effect of the secondary phase angles is neglected, which is permissible unless the test transformer is faulty, the detector can not be made to indicate a true zero, but adjustments are made to give a minimum reading.

A wattmeter need not be used as a detector, for very good results have been obtained in the field by using a copper oxide rectifier in conjunction with a sensitive milliammeter as "null" detector. Precaution is necessary that another a.c. voltmeter be used in place of this rectifier and milliammeter until the polarity has proved correct and the adjustment made to give a zero reading.

Up to this point in the discussion it has been taken for granted that the standard potential transformer has a voltage rating lower than that of the test transformer. It is quite obvious that the standard might be of higher rating; for instance, we have made tests on a 33,000-volt transformer using a 66,000-volt transformer as standard. In this case, the standard 66,000-volt potential transformer was conveniently available at the location of the test transformer and was so moved in under the bus structure that one lead could be taken up to a point between the fuse and the high voltage bushing of the test transformer. The other ends of both transformers were securely grounded, as is always necessary.

In cases where the test transformer is delta connected, it follows that the standard transformer must have both ends of its high voltage winding brought out through two high voltage bushings.

The above tests need not be limited to potential transformer testing. Power transformer windings and taps might be checked in an exactly similar manner.

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## *Oscillographic Measurement of Time Intervals*[2]

*A method is described for connecting up an oscillograph with an initiating and time delay relay for measuring short intervals of time.*

THE use of the oscillograph as a means of determining time intervals of short duration is meeting with considerable success, especially where the time interval in question is extremely short or where fractions of a cycle are involved, which, of course, are outside the range of the ordinary cycle counter.

The oscillograms, Figs. 1 and 2, are two of many recently made by the standardizing laboratory of the Southern California Edison Company Ltd. shop-test department at Alhambra, during the process of adjusting some special relays for contact closure with exactly a 4.5 cycle time delay following the excitation of the operating coil.

In these oscillograms the direction of time is from left to right as indicated by the arrow. The lower wave represents the current energizing the operating coil of the relay under test. The center line represents the closure of the relay contacts at the point of deflection of the line. The upper wave represents a 50-cycle timing wave used as a reference base for the determination of cycles required for the operation of the relay.

The schematic diagram of connections (Fig. 3) involves only standard equipment, readily available without special preparations for use, with an oscillograph in which the remote control switch is released with the excitation of the shutter trip magnet. This remote control switch is employed as the means of exciting the operating coil of an initiating relay, in which the time delay of contact closure is under control; this permits the excitation of the operating coil of the relay under test in a definite time relation, in accordance with the time lag requirements of the oscillograph shutter travel and the film speed.

The oscillograph is equipped with a range of adjustments for the position of the film driving pin and its relation to the shutter release mechanism which provides adequate range to meet most every requirement of film speed and placement of the transient.

A standard over-current relay may be used as the initiating control, and adjusted for contact closure to lag accurately the excitation of the operating coil of the relay under test at a pre-determined instant; this can be accomplished through the control of the initiating relay operating current and the position of the time lever setting.

Reference to the oscillogram, Fig. 1, shows the excitation of the operating coil of the relay under test at A, approximately 1.5 cycles (0.03 seconds) after the opening of the oscillograph shutter; this is indicated by the vibrator No. 1 whereas the closure of the contacts is shown 3.93 cycles or 0.0786 seconds later, by the deflection of the vibrator No. 2 at B. Vibrator No. 3 is a 50-cycle system voltage wave used as a timing reference.

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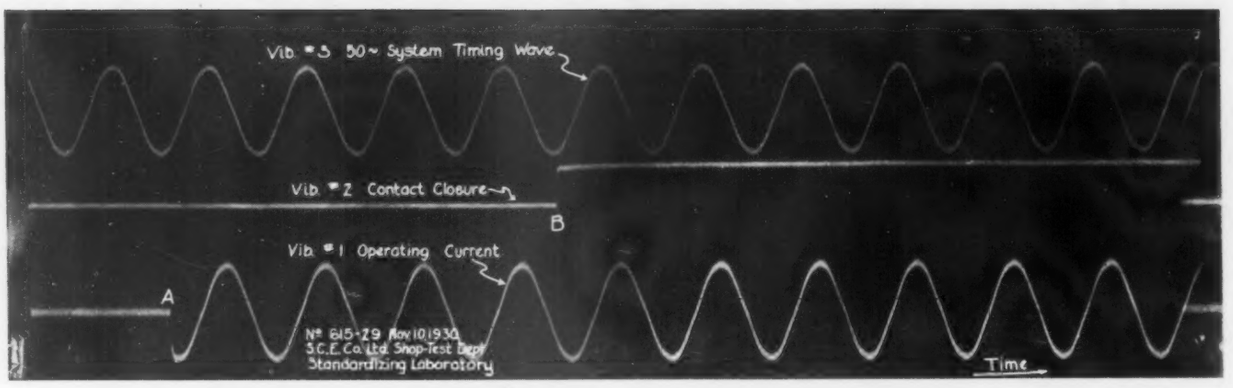
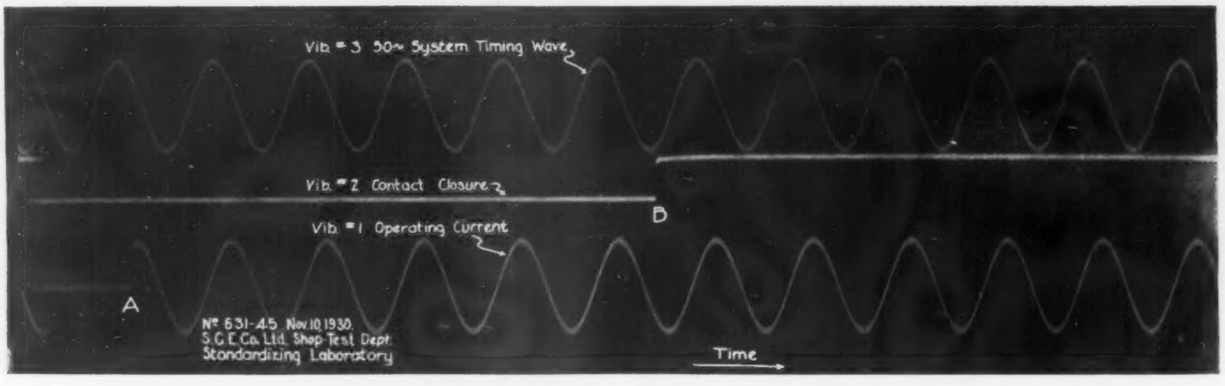
[2] Prepared by L. L. Conrad for the subcommittee on special tests and investigations, meter committee, Engineering Section.




*Figs. 1 and 2. Oscillograms made in relay closure time tests.*

The oscillogram shown in Fig. 2, by virtue of the same references, indicates that the contact closure at B occurs 5.37 cycles, or 0.1074 seconds after the excitation of the operating coil at A. Thus it is clearly shown that the difference of time intervals of 1.44 cycles, or 0.0288 seconds, is

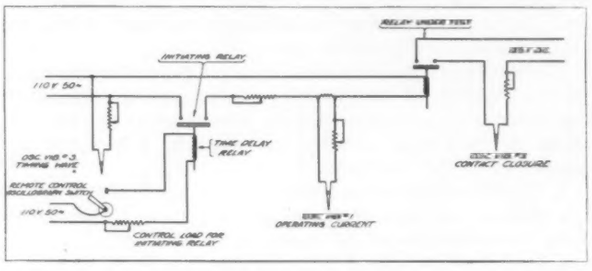



*Fig. 3. Schematic diagram of oscillographic investigation of relay closure time.*

represented by a lineal distance of approximately 1.5 inches. This time axis may be increased two or three times simply by leading the shutter control and increasing the film speed proportionately, therefore affording a very accurate means of time interval measurement.

In the process of the above test, each film was developed immediately after its exposure, affording examination and analysis at once, thereby permitting the adjustment of the relay under test without delay.

## *Investigation and Tests on Various Forms of Relays**

*Answers by companies to a questionnaire covering record of interruptions caused by faulty relays, tests on old and new relays, test equipment and special problems.*

IN order to gather information relative to investigation and tests on various forms of relays, the following questionnaire was mailed to the various companies located within the jurisdiction of the P. C. E. A.:

1. A detailed record of interruptions caused by faulty relays, so that the committee may study the data in order to eliminate the causes of trouble if possible and also aid in determining proper routine test schedules.
2. Reports on special tests of old relays and acceptance tests on new relays.
3. Test equipment used, especially new devices and compact units.
4. Any particular problem or experience that you may have had the past year which would benefit the men interested in maintaining relays.

No attempt has been made to summarize or abstract the reports as submitted because the answers are very brief and quite diversified.

### Southern Sierras Power Company

1. We have had quite a number of cases of trouble on the impedance relay we use, in that dust or grit gets in the

* Report of subcommittee on investigation and tests on various forms of relays, meter committee, Engineering Section. J. H. Vivian, chairman.

solenoid of the restraining coil and as the clearances between it and the core are very slight, it is sufficient to affect seriously the operation of the relay. We should like to inquire if this trouble has been experienced by the companies that are using this type of relay.

2. We have built up an instantaneous type of relay or contactor for use on ground protection of circuits, where it is not required that such protection be directional. This device consists of a standard relay contactor switch and is mounted in a relay case, in connection with an operation indicator. We find that this gives us dependable operation, where bushing transformers are used and the primary current values are rather low, functioning on currents approximately half those required by the low energy type overcurrent relay.

3. Our test equipment is about the same as the general type used by the other companies, except that we use a very flexible welding cable, which we find none of the other companies are using, and we also make use of a loading transformer made of circular lamination and using a stack of about 8 in. We wind 220 turns of No. 10 wire, operating at one volt per turn of the primary and merely threading the welding cable through the opening for the secondary; the number of turns being determined by the current required in the testing circuit.

4. We have also experienced difficulty with target operation which, we find, was due to cracked magnets. By transposing them or replacing them, we overcame this trouble.

### Los Angeles Bureau of Power & Light

1. From a total of 623 relay operations on our system during the year, 603 were classified as correct and 20 were classified as incorrect. From the twenty incorrect operations, six were on 2.2-kv. and 4.4-kv. feeders; two of these were due to bent shafts and four to contact trouble. Fourteen incorrect operations were experienced on the 33-kv. system.

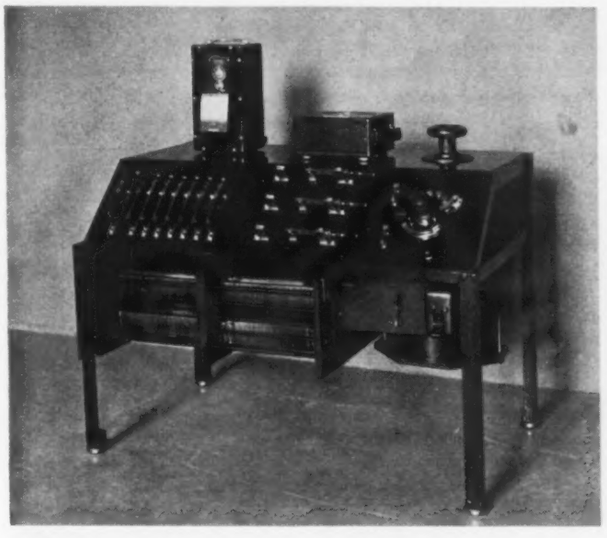


*Fig. 1. Portable test table, Los Angeles Bureau of Power and Light.*

Of these, two were caused by open potential on impedance type relays, one by impedance element being out of balance, seven by surges between generating stations, through impedance type relays, and four by low time setting of excess current relays.

2. All relays removed from service are sent through the testing laboratories, where any necessary repairs are made and the relays given a complete laboratory test before being returned to stock. All new relays are given a complete laboratory test before being placed in stock.

3. Our portable relay test table has been rebuilt and several new features incorporated. A small induction regulator is used to maintain the voltage on the table and is connected to the table by a multiple contact plug connector, with switches located on the table for changing the regulator connections. A dial switch is used to change ratio on a current transformer and on the lowest step, cuts out the trans-

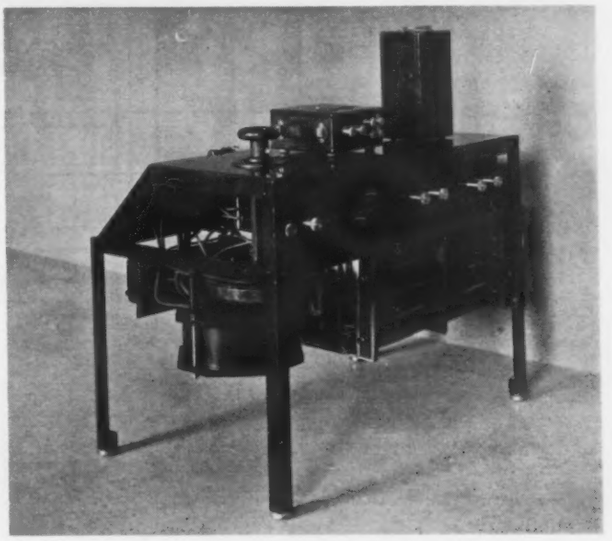


*Fig. 2. Test table, rear view.*

former and connects the ammeter directly in the circuit. Another feature that has proven itself quite worthwhile is semi-automatic control, in which a test run is started by pushing a button and automatically stopped by the relay, when the run is completed. This reduces heating of the relay to a minimum, when testing at high current values and speeds up the testing quite materially. Two photographs and a wiring diagram of the portable test table are shown in Figs. 1, 2 and 3.

4. Several of our lines cannot be conveniently removed from service for a testing of their relays, so, in order to overcome this difficulty, a set of three excess current relays was mounted in a portable cabinet and flexible leads brought out so that they could be connected in the circuit, while the regular relays were being tested. This eliminates leaving the line entirely unprotected while testing its relays or waiting until the line can be taken out of service.

### Southern California Edison Company Ltd.

1. The following table gives a good summary of the automatic switch operations for the year 1930.

It will be noted that six defective relays caused trouble. These relays were found to have troubles such as grounds, sticking contactors and bad contacts.

*Southern California Edison Company Ltd. Yearly Summary of Grounds, Short Circuits, and Automatic Switch Operation*

| | | Total |
|---|---|---|
| 1. | Total number of grounds and short circuits | 1,570 |
| | (*a*) Grounds on isolated neutral systems not possible to be cleared | 163 |
| | (*b*) Grounds and short circuits possible to be cleared | 1,407 |
| 2. | Test reclosures possible to be cleared | 551 |
| 3. | Total cases possible to be cleared | 1,958 |
| 4. | Cases cleared correctly | 1,894 |
| 5. | Per cent cleared correctly | 96.8 |

*Automatic Switch Operations*

| | | |
|---|---|---|
| 1. | Breaker operations required | 2,398 |
| 2. | Failures to operate | 58 |
| 3. | Unnecessary operations | 73 |
| 4. | Back up breaker operations | 69 |

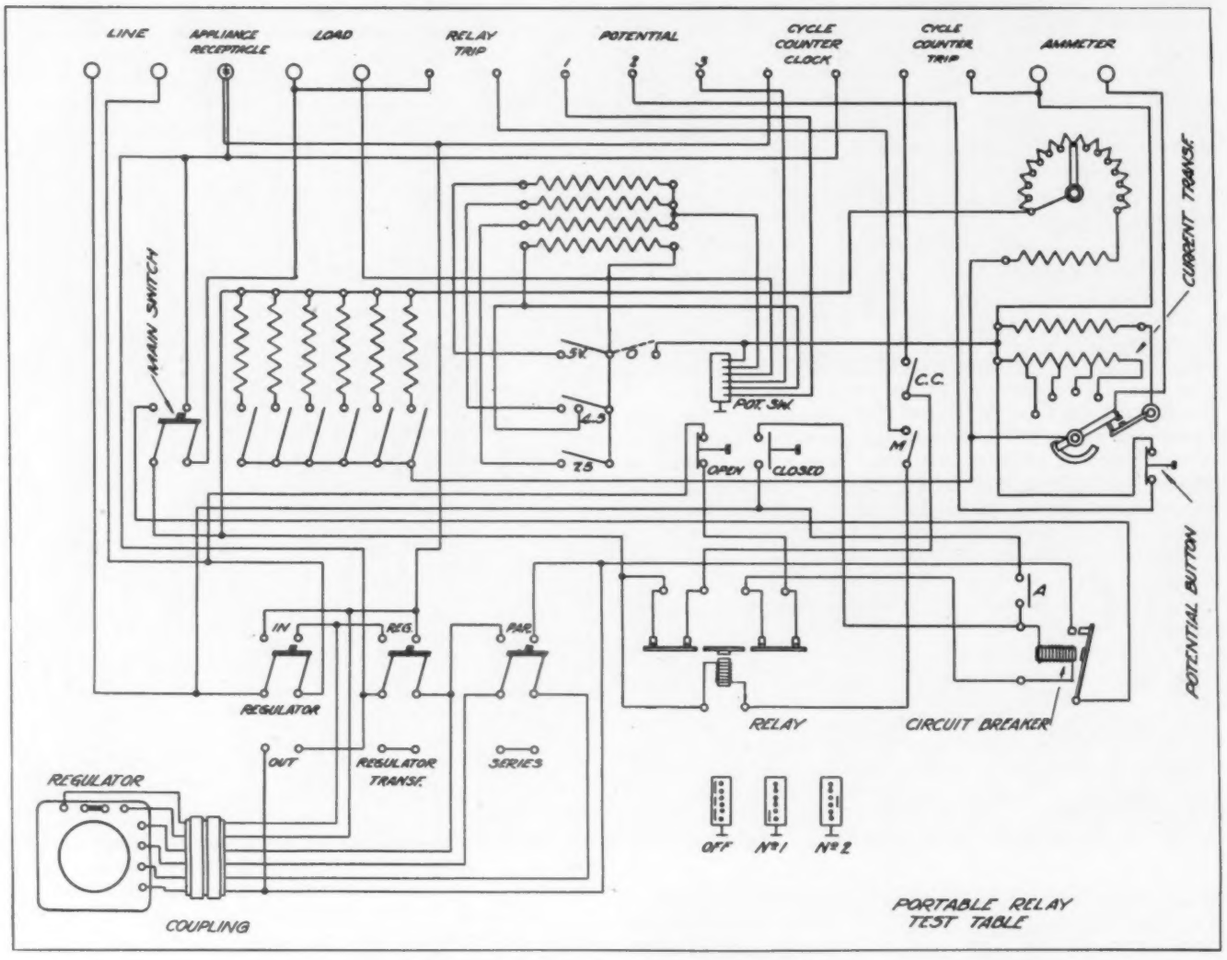



*Fig. 3. Wiring diagram of portable test table.*

*Causes of Unnecessary Operations*

| | |
|---|---|
| Defective relay | 6 |
| Defective switch mechanism | 7 |
| Defective electrical equipment | 9 |
| Incorrect wiring | 7 |
| Errors by personnel | 9 |
| Loss of potential on reverse power relays | 4 |
| Poor relay setting | 18 |
| Poor application of relay | 4 |
| Inadequate protection provided | 3 |
| System design | 1 |
| Abnormal operating conditions | 1 |
| Unknown | 4 |
| | 73 |

*Causes of Failures to Operate*

| | |
|---|---|
| Defective switch mechanism | 15 |
| Defective electrical equipment | 6 |
| Loss of potential on reverse power relays | 9 |
| Poor relay setting | 1 |
| Poor application of relay | 1 |
| Inadequate protection provided | 19 |
| System design | 2 |
| Unknown | 5 |
| | 58 |

2. Many cases of trouble were averted because of our rigid field routine schedule. As the relays are removed from service, they are sent through the laboratory for repair and test before being placed in the general store stock.

All new relays are given a complete test before being placed in stock and relays of new design are given a complete investigation which includes family curves.

3. The test equipment is the same as described in the report of this committee two years ago. Because of the fact that the relay testmen make tests on all other station apparatus, the compact units would not be practical.

4. Several investigations have been made on relays during the past year, the most outstanding one being a test on the directional ground relays. This test was made to determine a method to change the phase angle relation between the current and potential circuits, so that the relays would have a maximum torque when the power factor of the line in trouble would be lagging approximately 70 degrees.

Another important test mas made on one type of differential relay. This test was made to determine whether or not the relay could be used for differential protection having similar characteristics to another type. With minor changes, this was accomplished and several are now operating on the system. This method of use was necessitated because of an overstock of relays of the first type mentioned.

Anyone interested in the complete details of these tests or any other further details of this report may obtain information by writing the chairman of this committee.

## *Operating Problems of Meter Department**

*Operating problems of the meter department, such as the selection of meter sizes, theft of current, checking field standards, testing current and potential transformers, the keeping of meter department records and the question of transportation for meter testers are here considered.*

ONE of the most important operating problems of a meter department is the selection of wattmeter sizes, in amperes, for various connected loads, and in this connection, the report of the subcommittee on obsolescence of electric meters should be very carefully considered.

### Selection of Meter Sizes

Special tests on various types of watthour meters, both obsolete and the newer types, were made by the Southern California Edison Company Ltd., and very interesting results obtained, which would indicate that it is possible to use the older type meters on certain installations. However, such installations should be watched very closely, as a check made recently indicated that it is impossible to know at the time the meter is installed what the final load will be. A large number of 5-amp. meters which were put into service in the last five years showed a connected load all the way from 300 to 400 per cent, and a number of cases were found where the current coils of the meters were burned out.

### Theft of Current

The theft of current being a very serious problem with all companies, the following procedure, which has been worked out satisfactorily by one company, will be of interest.

If a theft is discovered or suspected, a representative of the investigation department and one of the meter department make a complete survey of the installation, figure as nearly as possible the length of time the theft has been going on, estimate the amount of current used, and present an estimated bill to the party involved. A general inspection once a year would probably prove valuable in the detection of theft of current.

### Checking Field Standards

If field standards are checked and adjusted once a week, they should give little trouble. Where current and potential transformers are involved and tests are made for large consumers, it is necessary to make a more elaborate test, taking temperature, etc., into consideration.

### Testing Current and Potential Transformers

It is the practice of some companies to test all current and potential transformers before reinstalling. A number of companies make field tests; this is true, especially in southern California, where over-all tests are made.

### Meter Department Records

From observation it would seem that there are usually too many records kept in a meter department. We are of the opinion that these should be cut to a minimum and that records duplicating those which are required in the general office should not be kept by the meter department. However, this is influenced to a great extent by the location of the meter department with reference to the general office.

### Transportation for Meter Testers

There are certain classes of tests which require automobile transportation, and it is the practice of some companies to use automobiles exclusively for all testers. However, there are districts where street cars can be used to advantage.

* Report of subcommittee on operating problems of meter department, meter committee, Engineering Section. W. H. Talbott, chairman.

# OVERHEAD SYSTEMS COMMITTEE REPORTS[1]

## *Grounding**

*Your subcommittee does not believe that it has thoroughly covered the subject during the past year, nor that this report should be regarded as complete. We believe that the facts and findings set forth herein may be of use in preparing the way for a more complete understanding of the particular phases of this subject. We believe that much of the apprehension felt in certain quarters as to the dangers and hazards of grounds will be removed after an open minded study of the subject. We believe that it is not only desirable, but necessary, for interested members of the central station industry to carry on a program of education in order that the true facts of the situation may be known and groundless fears dissipated. This is particularly true of the interests affiliated with the water piping systems, of which further mention will be made later.*

*A previous report on "Electrical Grounds" was presented by F. H. Mayer as a report of a joint subcommittee from the electrical apparatus committee, overhead systems committee and safety rules committee of the Pacific Coast Electrical Association in 1926 and was published in the May 15 issue of the Journal of Electricity.*

* Report of subcommittee on grounding, overhead systems committee, Engineering Section. R. R. Cowles, chairman. C. A. Bennett, J. O. Binney, D. I. Cone, L. C. Edwards, A. S. Glasgow, C. E. Ingalls, H. N. Kalb, C. W. Lightner, E. A. McGinty, G. A. MacDonald, C. T. Mess, E. Y. Porter, G. A. Riley, E. R. Stauffacher, E. M. Wright, C. E. Young.

[1] J. O. Tobey, Pacific Gas and Electric Company, chairman. D. D. Smalley, San Joaquin Light & Power Corporation, vice-chairman.
Allis-Chalmers Manufacturing Company: F. H. Searight.
Aluminum Company of America: Walter Hayes.
California Railroad Commission: C. T. Mess.
City of Glendale: F. Diederich.
Coast Counties Gas & Electric Company: A. E. Strong.
Copper Weld Steel Company: C. E. Ingalls.
General Cable Corporation: J. E. Crilly.
General Electric Company: C. R. Benson, J. C. Porter, W. C. Smith.
General Electric Supply Corporation: G. A. Hart.
Graybar Company: A. R. Fryklund.
Joint Pole Association: R. E. Hill, J. E. MacDonald.
K-P-F Electric Company: A. J. Pahl.
Line Material Company: F. J. Gleiss.
Los Angeles Bureau of Power & Light: H. L. Caldwell, O. W. Holden, G. A. MacDonald, A. L. Williams.
Los Angeles Gas and Electric Corporation: F. E. Dellinger, C. B. Judson, E. R. Northmore, G. A. Riley, R. M. Spencer, H. B. Wells.
W. N. Matthews Corporation: B. C. Hoist.
Maydwell & Hartzell: H. F. Hartzell.
Ohio Brass Company: J. B. Naugle.
Pacific Gas and Electric Company: N. P. Carlsen, Jr., M. W. Clark, Roy Cowles, O. R. Evans, J. W. Finchley, J. R. Jensen, A. M. Jepperson, Homer Keesling, C. S. King, John B. Madden, Joe Mini, J. B. Moorehead, R. W. Muller, E. A. McGinty, L. B. Smith, Paul Suransky, C. P. Taylor, L. F. Theis, C. L. Yager, C. E. Young.
The Pacific Telephone and Telegraph Company: D. I. Cone.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow, C. L. Lawrie.
San Joaquin Light & Power Corporation: E. R. Banks, Roy Hall, H. N. Kalb, C. W. Lightner, H. H. Minor, H. H. Shields, C. C. Wilson.
H. B. Squires Company: E. S. Moreland.
Southern California Edison Company Ltd.: C. A. Bennett, J. O. Binney, F. E. Blausey, R. G. Boyles, C. B. Carlson, W. B. Champion, C. V. Fairchild, R. B. Guilbault, C. E. Heath, J. F. Hodges, H. Michener, G. M. Richardson, W. E. Row, Ray Sheppard, E. R. Stauffacher.
The Southern Sierras Power Company: W. B. Loper, E. Y. Porter, A. C. Putnam, H. J. Schomberg.
Taper Tube Pole Company: Clinton DeWitt.
Westinghouse Electric & Manufacturing Company: C. A. Andrews, S. L. Case, C. C. Potts, A. W. Pride.

*Your subcommittee has endeavored to avoid duplication of the work of that committee, but we have found information contained in the former report to be of value and advantage has been taken of it. A number of new developments have occurred since the preparation of that report, while the adoption of the common neutral system in California has placed the subject on a somewhat different plane. The subcommittee feels that review and amplification of this important subject is particularly timely and that it could well be carried over for future years' study or reviewed at such intervals of time as changes may occur in the art and as our practices adapt themselves to such changes.*

THE subject of grounding has been given more or less attention for the past twenty years. It is only in recent years, however, that more intensive study has been given this subject and this has been brought about by the knowledge of the greater importance of adequate grounding, as the capacities of electric systems have increased and as their effect upon other properties has become more apparent. A satisfactory ground for a system of a few hundred kilowatts capacity, operating over a limited area, would not be adequate for a modern system with an interconnected generating capacity running close to 1,000,000 kw.

The trend toward solidly grounded systems for transmission, distribution and utilization is becoming increasingly apparent. Whereas, a few years ago, solidly grounded electrical systems were in the minority, we now find that nearly all of the newer installations are arranged for Y-connection with a solidly grounded neutral. Interior wiring methods have changed and now we find identified conductors with neutral wire solidly grounded, single-pole fusing and in some localities bare-grounded neutral wires, conduit return systems and concentric wiring, all involving the same principle. Grounding of non-current carrying parts of motors, generators, transformers, switches and conduits has been required for a number of years and the rules requiring the grounding of portable electrical devices are rapidly being put into effect. The common primary and secondary grounded neutral system which is becoming established in California has given us another reason for embarking upon the study of the very important problem of grounding.

## Purposes and Principles

Grounding of the electrical systems and equipment is in general for the following purposes:

1. Protection of life and property.
2. Continuity of electric service.

An adequately grounded conductor or piece of apparatus should meet the condition that an undue or dangerous potential above the nearby earth shall not under any condition exist. Obviously, this condition will depend upon the voltage of the supply system, character of the soil, type of ground and ground connection used, all of which influence the amount of current which may flow into the ground when the condition for which this protection is devised actually occurs.

There are certain things that a ground should do and certain things that it should not. Due principally to the inductive influences on other circuits, it is generally accepted now that the grounding of conductors of any system is for the purpose of stabilization and not for use as a return conductor. In this case stabilization serves its purpose as a safety measure, in draining the flow of current and preventing the existence of harmful potential. As a safety measure, therefore, the effectiveness of the ground is dependent entirely upon its conducting ability, which means that the ground must at all times provide as low a resistance path as exists in the surrounding conducting surfaces and it must be capable of absorbing a considerable flow of current in order to prevent dangerous high potentials above ground.

In speaking of "adequate" ground, we have taken it as meaning one which, with maximum possible current flow to earth, will prevent a harmful voltage from existing between the grounded conductors and adjacent exposed conducting surfaces at ground potential or with adjacent surfaces of the earth itself. It is difficult to set forth a clear and concise interpretation of the word "harmful" since the voltage involved has an extremely wide range, due to the many variables which may exist in practice.

Considering any form of ground connection, the total electric resistance to the flow of current away from the connection to earth can be divided into four parts:

1. Part contributed by the ground wire and its connections to the grounding electrode and to the apparatus it is designed to serve.
2. Part contributed by the ground electrode itself.
3. Part contributed by the contact between the ground electrode and the soil.
4. Part contributed by the soil itself.

It is the combination of all of these which produces the net result.

The resistance of the ground wire is usually negligible in comparison with the total resistance, particularly since the general practice in grounding is to use a reasonably large cross section of copper conductor. This feature is covered by various rules, specifications, laws and ordinances and, in general, it is the best part of the grounding system. The resistance of the earth itself is small because of its large volume, resulting in an infinite number of multiple paths. Nearly all of the soil resistance is in the contact between the electrode and the earth and this is by far the most critical part of the grounding system. The fact that the greatest resistance, and hence the greatest difference of potential, is in the soil immediately surrounding the electrode, which is the region of smallest cross section of the soil, is important and all methods for improving "ground conductivity" have taken this factor into consideration. Measurements made on driven pipe grounds, for example, show that 90 per cent of the total electrical resistance surrounding the pipe grounds will ordinarily lie within a radius of six to ten feet from the pipe. See Fig. 1.

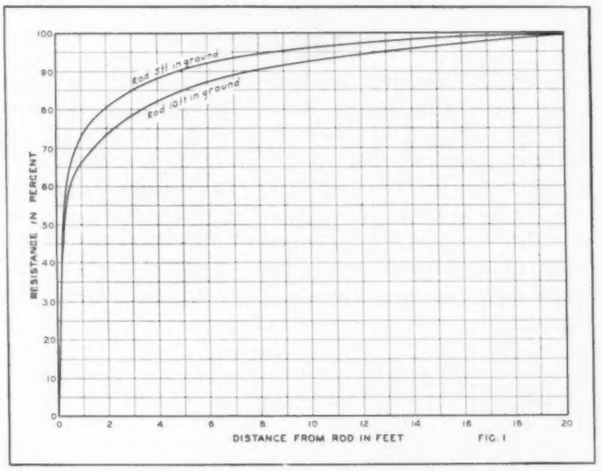



*Fig. 1. Measurements made on driven pipe grounds.*

If we consider the areas of current paths as a succession of spheres surrounding an electrode, these areas will increase as the square of their distance from the electrode. If the soil is of uniform resistance, the resistance offered to flow of current from the electrode will decrease directly in proportion to the area of possible paths and inversely as the square of the distances. Fig. 2 shows typical conditions when two grounding electrodes C-1 and C-2 are driven into soil of uniform conductivity, the size of the electrodes being small as compared to the distance between them. It is assumed

that current flows into the earth through one electrode and out through the other. The dotted lines indicate paths of current flow and the solid lines equal potentials near the surface of the earth.

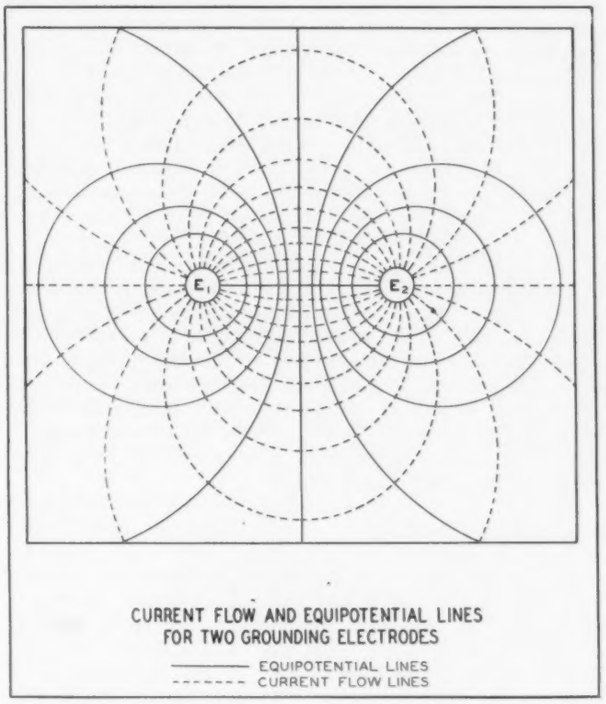



*Fig. 2. Current low and equipotential lines for two grounding electrodes.*

It has been recognized that the securing of "adequate" grounds at all times, in all locations and under all emergencies which may arise is a very difficult one. The situation is, however, far from hopeless, because we know that we are now actually meeting grounding conditions as the need arises and as experience makes it possible, and there is at least one type of ground which all electrical men have agreed is both adequate and satisfactory.

## Laws and Regulations

*California Electrical Safety Orders —*

The Electrical Safety Orders issued by the Industrial Accident Commission of the State of California state that "Grounding is required primarily for the protection of persons. If the grounding connections have not been properly met, the desired protection will not have been provided and a hazardous condition may exist." This order further states that, where low potential circuits, equipment, conduit, etc. are grounded, they shall be so arranged that under normal conditions of service there will be no objectionable passage of current over the grounding conductor. This order also provides for mechanical protection of the grounding conductor and the connection to the grounding electrode and recommends ground to underground water piping systems wherever possible.

The combined resistances of the grounding wire and the connection with the ground shall not exceed 3 ohms for waterpipe connections nor 25 ohms for buried or driven grounds. Where it is impracticable to obtain, with one ground, ground resistance as low as 25 ohms, two artificial grounds, at least 6 ft. apart and with a combined area of not less than 4 sq. ft., shall be provided.

The exposed non-current-carrying metal parts of all utilization equipment on circuits operating at 150 volts to ground or over, shall be grounded, unless such metal parts are effectively guarded so that persons cannot come in contact with them.

The path to ground provided for a circuit shall, in general, have a current-carrying capacity sufficient to insure the continuity and continued effectiveness of the path under conditions of excess current caused by accidental grounding of any normally ungrounded conductor of the circuit. The grounding conductor shall be of copper or of other metal which will not corrode excessively under the existing conditions and, where practicable, shall be without joint or splice. The insulation and installation of the grounding wire for circuits, when not protected by metallic piping, shall comply with all requirements of these orders applying to wires of the voltage of the circuit to which the grounding wire is attached. When a circuit grounding wire is installed in metallic piping and is bonded to it at both ends, a bare copper conductor may be used. Ground clamps and all grounding wires which are smaller than No. 4 in size shall be protected from ordinary mechanical injury by being placed where they are not liable to be damaged or by being inclosed in metal, wood or equivalent protective covering. In the case of a lightning arrester grounding wire, the protection shall be composed of non-magnetic material, unless the grounding conductor is electrically connected to both ends of the protective covering.

Whenever possible, grounding shall be obtained by connection to an underground water piping system. The water pipes shall have a carrying capacity not less than that of the grounding conductor attached thereto. In lieu of connecting the grounding conductor directly to a water pipe, it may be connected to a galvanized pipe screwed into a suitable clamp or device which is securely fastened to a water pipe. Grounding connections may be made to the steel frames of buildings (except buildings in which highly explosive or inflammable substances are stored), provided such frames are permanently and effectively grounded. Grounding connections may be made to well casings or pump-intake lines when the intake is continually submerged or is buried in the ground, where moisture is prevalent. Any device which is liable to interrupt the continuity of a grounding system shall be shunted by a bond which will provide conductance equivalent to that of the grounding conductor.

Gas piping systems within buildings shall be used as a ground only when water piping is not available, and then only for grounding equipment; provided, however, that gas piping may serve as the sole ground for small fixtures located at a considerable distance from water piping. Where gas piping is so utilized, it shall be bonded to the water piping systems, at their point of entrance. Gas piping need not be insulated from otherwise well grounded fixtures.

Rails or other grounded conductors of electric railway circuits shall not be used as a ground for other than railway lightning arresters, and railway equipment, conduit, armored cable, metal raceways and similar equipment, when other effective grounds are available.

This order further requires that service conduit shall be permanently and effectively grounded and that the grounding conductor shall be connected to the service conductor ahead of the service switch.

*National Electric Code —*

The 1930 edition of the National Electric Code in general follows the same requirements as the California Safety Orders, although the latter were prepared and edited in 1925. The same general requirements, "shall be so arranged that there will be no objectionable passage of current over the grounding conductors," is included, but the code recognizes unusual conditions and states that "temporary currents, which are set up under accidental conditions while the grounding conductors are performing their intended functions, are not to be considered objectionable." The code requires permanent and effective connections and conductors and that the connection be made to a continuous metallic undergound water piping system if one is available. "In the absence of such a water piping system, a system ground conductor or a secondary neutral grounded grid shall be used, if available." Where none of the above are available, any of the following may be used:

1. The metal frame of a building, when effectively grounded.
2. A continuous metallic underground gas piping system.
3. A local metallic underground piping system, metal well-casing and the like.
4. An artificial ground whose electrode consists of a driven pipe, driven rod, buried plate or other device approved for the purpose.

"Artificial grounds, when used, should be imbedded below permanent moisture level, and, if buried plate electrode is present, in less than 2 sq. ft. of surface to exterior soil. Electrodes of iron or steel pipe shall be galvanized, of not less than ¾-in. internal diameter, and if non-ferrous material, shall not be less than ½ in. in diameter and all driven electrodes shall, except where rock bottom is encountered, be driven to a depth of at least 8 ft., regardless of size or number of electrodes."

The code specifies the same values of resistance as the California Safety Orders and permits two grounds at least 6 ft. apart where the value of 25 ohms cannot be met by a single ground.

*General Order 64A of the California Railroad Commission—*

This defines permanently grounded:

Permanently grounded means connected to earth in such manner that no current which can flow in the ground wire will cause a harmful voltage to exist between the grounded conductors and facilities and adjacent exposed conducting surfaces which are in good contact with the earth or with adjacent surfaces of the earth itself, under the most severe conditions which are liable to arise in practice.

If a resistance of less than 25 ohms is not obtained, the equivalent of two ½-in. corrosion resisting rods, not less than 8 ft. in length and continuous throughout, driven to a minimum depth of 8 ft. at not less than 6-ft. centers will be considered a permanent ground for the purpose of these rules.

This order also specifies that the grounding of the neutral in single-phase or polyphase systems is permitted only for the purpose of stabilizing the neutral of the system and not for use as a return conductor. Independent grounds or independent ground connections are required, the resistance of which does not exceed 25 ohms for:

1. Lightning arresters.
2. Low voltage power or lighting circuits.
3. The neutral wire of four-wire three-phase systems where the line voltage exceeds 2,500.
4. Grounded bond wires.

This order further requires grounding of hardware on pole structures under certain conditions deemed necessary in the interests of safety to life.

Rule 32.4 which required independent ground connections for low voltage circuits and 4,000-volt primary circuits, is, of course, in conflict with the principle of the common primary and secondary grounded neutral. Over three years of study have been given to this subject, in which the engineers of the Railroad Commission have actively participated. The construction requirements for common and secondary neutral on overhead distribution lines, as tentatively prepared by the Railroad Commission, require that the resistance of the continuous metallic neutral grid to ground shall not exceed 3½ ohms at any time, and the measurements may be made by any of the present day approved methods. Grounds are required on the common neutral grid system at intervals not greater than 1,500 ft. and where return loop paths are not available, the distance is reduced to 800 ft.

Ground rods, when used, shall be of one piece metal not less than ⅝ in. in diameter or 8 ft. in length, of corrosion resistant material and driven to a minimum depth of 8 ft. below the surface of the ground. Ground wires, when connected to a water pipe system, must be installed on the main line side of the water metering equipment.

When two or more driven rods are installed, the same 6-ft. separation is required, as stated in the two other regulations above. Rods shall not be less than 2 ft. from the surface of the pole.

In the case of branch circuits radiating from the main grid section, where a separate return metallic path is not available, line grounds shall be installed at not greater than 800-ft. intervals and each transformer installation shall be so located that one or more water pipe systems grounds are installed on each side of the transformer installation.

It has been suggested that a more accurate measure of the effectiveness of the grounding system for the common primary and secondary distribution would be "the resistance of any part of the neutral grid to the ground connection at the substation," and it has been furthermore suggested that the value of such resistance be made a maximum of one ohm. As a measure of safety to life and property, the ability of the grounded neutral grid system to return the current to the substation grounded neutral connection is the all important item. It, therefore, appears that this limitation of the resistance of the neutral path to the source of energy is really the correct measure of safety, rather than the resistance of the neutral grid to the nearby earth.

## Types of Grounds

*Water Pipe System—*

The National Electric Code and various orders of state accident and utility commissions have quite uniformly recognized the effectiveness of a metallic water pipe system as a grounding medium. The study of this subcommittee bears out this conclusion and there can be no doubt that a permanent connection to a metallic water pipe system offers as nearly as possible the ideal grounding condition. In all cities and also for some distances in suburban territory, water pipes are usually available. Fortunately, this availability occurs in the localities where the need for adequate grounding is greatest. The grounding of conduits and electrical apparatus on the consumer's premises to the water piping systems has been in general practice throughout most of the United States for at least the past 15 years.

The practice of grounding a.c. distribution systems, particularly the neutral wire of a 4,000-volt network to the water piping system, has not been extensively followed, although there are a number of instances and localities where it is well established and has the approval of the water supply officials. The practice of grounding electrical power circuits to water pipes has from time to time been questioned by the water supply people. In fact, they have recorded objection to the unco-ordinated use of such underground structures for electrical grounding purposes.

*N.E.L.A. Questionnaire*—During the past year N.E.L.A. headquarters circulated a questionnaire in order to determine the nature and extent of the use of water pipes by electric supply companies for grounding purposes. Replies were received from more than 100 companies well distributed throughout the country. Responses were received from October, 1929, to April, 1930, and it is assumed that the results represent practices existing at the end of the year 1929.

The results show that:

87 per cent of the companies reported water pipe grounds made at the consumers' services.

28 per cent reported grounds at mains and transformer secondaries.

20 per cent reported grounds at primary neutrals.

17 per cent reported grounds at substations.

11 per cent reported grounds at lightning arresters.

Since the above percentage was based on the number of companies and not the size of the electric systems involved, the replies were again analyzed so as to take into account the number of consumers and the size of the systems, which would be a more correct indication of the actual preference of water pipe grounding. On this basis, the weighted ratios are as follows:

94 per cent of the consumers' services are grounded to water pipes.

51 per cent of mains and transformer secondaries grounded.

39 per cent of primary neutrals grounded.

If the above figures can be considered as representative of conditions in the United States, as there appears no reason for doubt that they do, it becomes apparent that the grounding of consumers' services and apparatus to water pipe is practiced almost uniformly throughout the United States and that more than half of the mains and transformer secondaries are likewise grounded. The percentage of primary neutrals grounded to water pipe is surprisingly large, considering the fact that there are still a considerable number of electric distribution systems operating without a primary neutral.

The replies show that the grounding of electric systems to water pipes has been common practice in this country for many years and that such grounding has been carried on with the knowledge and consent of the water supply authorities. They show that where previous cases of electrolysis were found, such has been traced to the existence of stray currents from d.c. railway or other d.c systems and that electrolysis disappeared when the causes were understood and proper remedies applied.

The responses to the questionnaire were almost unanimous in their testimony that in localities where previous trouble had been caused by d.c. railway systems, better bonding of rails, improved feeder systems, etc., had eliminated such trouble and no cases of electrolysis had been reported for a number of years.

*Objections to Waterpipe Grounds*—Earlier acute electrolysis conditions, however, have left some of the officials in the water supply companies in a reluctant attitude toward grounding practices or any contact with electrical circuits, for that matter, and in a susceptible frame of mind toward criticism of such developments. These men have not studied the technical differences between the electrolytic effects of direct and of the newer alternating current. Power representatives might do well to bear this in mind when discussing such situations with water supply officials and be prepared to present the situation as it actually exists. Apparently there have been occasions where power companies, when establishing grounds, have inadvertently destroyed the effectiveness of insulating joints or other measures taken by water authorities to protect themselves from stray d.c. railway currents. Obviously this situation can and should be remedied by co-operative study of stray current conditions.

The water supply officials seem, however, to have two valid causes for complaint. The first is that the remedial measures used by water works to mitigate the effects of stray current electrolysis are sometimes (but apparently not very often) nullified by grounding connections to the water pipes. For example, an insulating joint in an important main may be effectually bypassed by grounding connections on both sides of it. The second is that a broken electrical neutral conductor, or infrequently an error in connections whereby an outside conductor is attached to the water pipe, has occasionally caused excessive currents or excessive potentials to exist on water mains.

The first of these cases is obviously one for co-ordination and lends itself quite readily to study. The second case is clearly an operating and maintenance problem; the errors are accidents and probably affect the electric system more seriously than the water system. Nevertheless, the water people complain that the electric companies generally do not respect their plant or their problems.

The water works people have, however, gone considerably beyond this in anticipating trouble from the more extensive use of the ground by electric power distribution systems, for which they appear to have no tangible evidence. The common neutral system seems to have aroused their fears especially. They seem to apprehend a repetition of the troubles experienced from street railway stray currents.

It has been suggested by N.E.L.A. headquarters that central station engineers may advantageously take pains to reassure water works authorities on this point, and among other things, indicate the outstanding differences in the two cases which are:

(*a*) That the electrolytic corrosion effects of alternating current are negligible compared with direct current.

(*b*) That, from considerations of service, voltage regulation and economy alone, it is impossible for the electric supply system to support stray or ground currents of anything like the magnitudes of the stray direct currents commonly associated with ground return railway systems.

(*c*) Where grounding is technically indicated for an electricity supply system and where water mains are not available, an extensive system of artificial grounds would be required. Hence, heavy stray currents, if they existed, would ultimately find their way to water mains in any case, as with street railways.

*First Installation in California*—The first case in California of which we have record, where the primary neutral system was solidly connected to the water piping system, occurred in Sacramento in 1926. The engineers of the Pacific Gas and Electric Company, recognizing the necessity of adequate grounds on the neutral of the 4,000-volt four-wire system at points other than at the substation, made arrangements with the Water Department of the City of Sacramento for permanent ground connections. It was believed that both service and safety demanded this type of grounding connection, and subsequent results have justified that conclusion.

After some study by the city authorities, permission was granted by letter for the attachment of some 23 grounds at points requested by the electric company, the city reserving the right to tap the mains and bill the company for the cost. The city engineers insisted that the grounds be so located as to give the least amount of interference with paved alleys and furthermore that the ground wires be properly guarded to prevent accidental disconnection.

The excavating was done by the Pacific Gas and Electric Company, after which the city engineering department was called upon, in accordance with its desires, to tap the water mains for a 1-in. standard water tap of the screw type. The Water Department installation consisted of a water tap, a 1-in. service cock and about 18 in. of lead pipe. To this installation our organization added sufficient ¾-in. galvanized iron pipe to reach the nearest pole and to extend up the pole approximately 18 in. above the ground where it was capped. Previous to this, a 24 in. length of No. 2 bare stranded copper wire had been brazed to the pipe cap. The No. 2 ground wire from the primary neutral was brought down the pole and spliced to the short length of wire on the pipe cap. In this case, since two dissimilar metals were used, brazing was considered the best method of attachment to prevent corrosion and the development of a high resistance connection. Before filling in the ditch, the service cock was opened to fill the pipe with water and was then shut off. The path from the neutral wire to the water main was made as direct as possible with no loops and with few angles and connections, to insure good grounds. The copper was of sufficient area to take care of the maximum discharge which might occur at that point.

Resistance tests were made of a few of the grounds using an ohmmeter of the Megger type, each of which measured less than ½ ohm. The method used was practically a three-point method, in that two auxiliary ground rods were driven —one 50 ft. and the other 100 ft. from the ground under test. The instrument measured the drop in potential between one auxiliary ground and the test ground, and the flow of current between the other auxiliary ground and the test ground. The instrument, being self calculating, applied Ohms law to the measurements and gave a direct reading in ohms.

Advantages of the water pipe grounding system are as follows:

1. Lower resistance than any other type of ground.
2. Resistance is constant at all times and does not vary with the moisture content of the soil.
3. The soil does not dry out to any appreciable extent, due to the flow of current through the pipe ground.

Water pipe grounds are undoubtedly the most satisfactory where good low resistance grounds are required. It is doubtful if the cost is higher for the low resistance obtained, than for average driven grounds obtaining as good conductivity.

*Driven Grounds* —

While recognizing that water pipes offer the most satisfactory solution of the grounding problem, there are many locations where this type of ground connection is not available. The driven-ground rod or pipe has, with certain limitations, proved a satisfactory substitute for the waterpipe ground and is used extensively throughout the United States. Chief among its advantages is the low cost of installation as compared to some other forms of ground electrodes and the simplicity of installation as compared to the work of excavating for and installing other types. Multiple grounds can be readily obtained by driving more rods or pipes, thereby providing flexibility for this system. Another advantage is that the connection between the ground wire and the electrode can be made above the surface of the soil, thus permitting ready inspection and testing, eliminating the possi-

bility of an obscure defect such as a broken wire below the surface.

The relative resistance values in the different components of the grounding system have been mentioned. That portion of the total resistance contributed by the soil is the most important part of any ground connection. If we consider a driven rod in soil of uniform conductivity, the greatest resistance is found in the soil immediately surrounding the rod, in the region of the smallest cross section of soil at right angles to the flow of current through the soil. (See Fig. 1). The variation in resistivity for soils of different composition, as actually found in different localities, varies from a few hundred ohms to a million ohms per c.c., and depends upon the ingredients of the soil, amount of moisture, and temperature. In a salt marsh, for example, the resistance is extremely low, being in the order of a few ohms, while in a dry, sandy country such as found in the desert region, the resistance approaches infinity. The soil near the surface is usually dry and somewhat non-conductive. Below this there is a stratum of semi-moist soil of various texture, and at some lower level there is usually found a stratum more or less saturated with moisture. One authority gives the average soil resistivity throughout the United States as lying between 2,000 ohms and 10,000 ohms per c.c.

It therefore becomes apparent that the depth to which an electrode is installed is a very important factor in its ability to carry off current, which is the measure of its effectiveness. The reasons for this are: First, the area of contact between the rod and the soil increases directly with the length of the pipe below the surface; second, the resistivity of the soil is less at greater depths. This condition is shown in Figs. 3 and 4, in which resistance is plotted for different lengths of rods and depths of penetration.

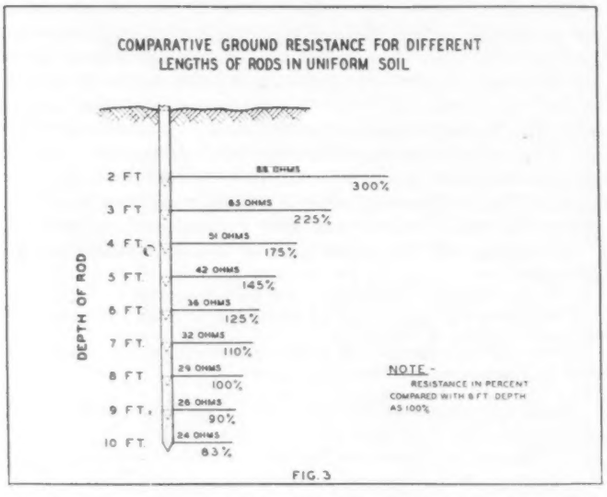



*Fig. 3. Comparative ground resistance for different lengths of rods in uniform soil.*

The necessity of reaching permanent moisture level is recognized as the principal aim in installing electrodes. This is stated in the National Electric Safety Code of the U. S. Bureau of Standards, in the National Electric Code and in similar publications. The former states: "Electrodes shall be driven, except where rock bottom is encountered to a depth of 8 ft., regardless of the size or number of electrodes used." The 8-ft. length as a practical standard was probably adopted through experience and engineering judgment and appears to be fully justified as a practical minimum standard. From a standpoint of economy, greater conductivity can be obtained per dollar of cost with longer electrodes. In this respect driven rods possess a definite advantage over some other types of electrodes, in that it is possible to drive to any reasonable depth in order to contact soil containing permanent moisture, as they are capable of reaching a depth of 20 ft. or more under average conditions.

Ground connections are capable of dissipating energy at a certain rate, which rate depends upon the moisture content of the soil, the rate and distance at which moisture will travel by capillary action, the size and number of electrodes,

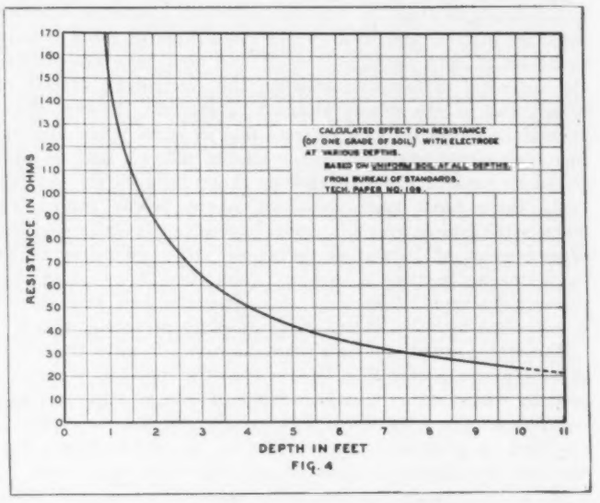

RESISTANCE IN OHMS
CALCULATED EFFECT ON RESISTANCE (OF ONE GRADE OF SOIL) WITH ELECTRODE AT VARIOUS DEPTHS.
BASED ON UNIFORM SOIL AT ALL DEPTHS.
FROM BUREAU OF STANDARDS.
TECH. PAPER NO. 108.
DEPTH IN FEET
FIG. 4

*Fig. 4. Calculated effect on resistance with electrode at various depths, based on uniform soil at all depths.*

temperature of the soil and the amount of chemicals, if any, found in the soil or used in connection with the electrode. If the rate of energy dissipation is exceeded, the soil will dry out, thus causing a greater increase in resistance. For example, it is found that a pipe driven 10 ft. in moist soil moderately salted will be able to dissipate energy at a rate of from 5 kw. to 20 kw. continuously without any appreciable increase in resistance.

1. *Copper, bare iron, galvanized iron* and other mteals indicate practically identical contact resistances with the soil. This fact is shown in some detail in Bureau of Standards Technologic Paper No. 108, "Ground Connections for Electrical Systems."

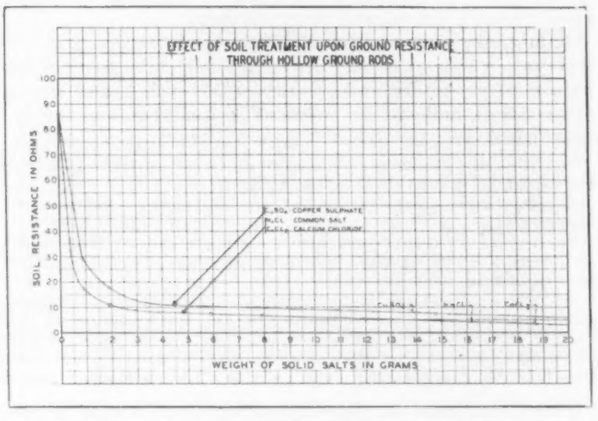

EFFECT OF SOIL TREATMENT UPON GROUND RESISTANCE THROUGH HOLLOW GROUND RODS
SOIL RESISTANCE IN OHMS
WEIGHT OF SOLID SALTS IN GRAMS

*Fig. 5. Effect of soil treatment upon ground resistance through hollow ground rods.*

In the above tests, several samples of earth were used, each thoroughly mixed before testing, in order to make the resistivity as uniform as possible throughout. Tests were made by placing different quantitites of the soil in a cylin-

drical glass vessel having an iron bottom, compressing it by forcing an iron piston down upon it, and measuring the electrical resistance between the piston and the metallic bottom.

Another series of tests made by the Underwriter's Laboratories on galvanized rods and rods with a copper exterior of various diameters driven to the same depths at several different locations, indicated that the resistance values lie in the same curve. Thus the material of which the ground rod is made has no practical effect on the resistance. It is also noted that hollow pipes and solid rods of equal outside diameter offered the same resistance to the flow of current.

2. *Very little change in resistance is obtained* by using large diameter rod or pipes. The soil surrounding the rod, rather than the diameter of the rod, determines the resistance.

Every test source consulted, showed that the difference in resistance is so little as between driven grounds of all diameters used commercially (that is from about ½ in. to 2½ in.) as to render the question of diameter of little practical importance. This is shown in Fig. 6. By doubling the diameter from ½ inch to 1 inch, an increase of 100 per cent in diameter and surface area, and 200 per cent in volume of earth displaced, the resistance of a single driven ground is decreased only about 12 per cent.

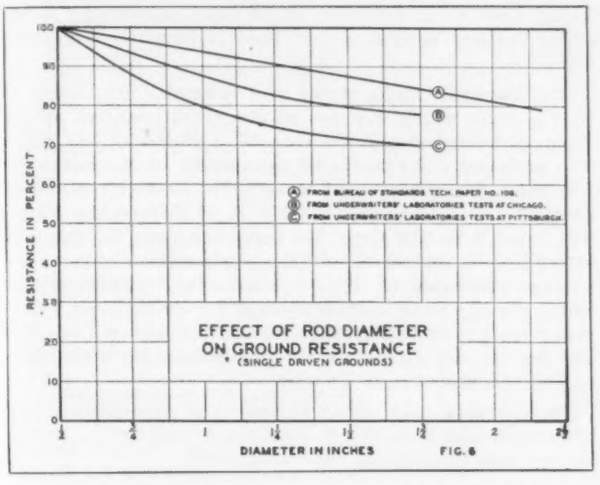



*Fig. 6. Effect of rod diameter on ground resistance.*

It is apparent, therefore, that the resistance of the ground connection is determined by the conductivity of the soil surrounding the electrode. This conductivity is dependent on the soil ingredients and the moisture content.

The important effect of the soil within a 5 to 6-ft. radius of the electrode can be easily demonstrated. For example, consider a ⅝-in. x 8-ft. driven ground which, when installed, has a resistance of 30 ohms. If a second electrode is driven immediately adjacent to the first and connected in parallel, there is only a slight reduction in resistance, although the contact area has been doubled. If the second rod is driven at a distance of 4 to 8 ft. from the first electrode, the resistance of the two in parallel is reduced about 40 per cent or to approximately 18 ohms.

3. *Penetration into the permanent moisture level* of the soil should be the aim in selecting the length of the driven electrode.

The driven ground should be long enough to reach permanent moisture. Failure to reach moisture may not only result in a high resistance, but may result in large variation of resistance during the changes in season. See Fig. 7. No driven ground should be less than 6 ft. in length and a minimum of 8 ft. is preferable. Longer rods may be used at times, but in most locations an 8-ft. length reaches permanent moisture and the use of a longer rod is not commensurable with improvements obtained by other means.

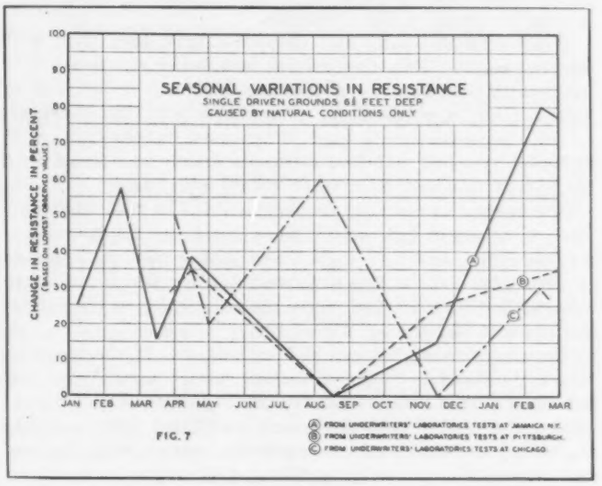

SEASONAL VARIATIONS IN RESISTANCE
SINGLE DRIVEN GROUNDS 6½ FEET DEEP
CAUSED BY NATURAL CONDITIONS ONLY
CHANGE IN RESISTANCE IN PERCENT
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR
FIG. 7

*Fig. 7. Seasonal variations in resistance.*

The variation in resistance with depth is shown in Figs. 3 and 4. With the first few feet, the benefit of additional depth is very pronounced, but the changes in resistance for depths greater than 8 ft. are small.

4. *Additional reduction in resistance* may be obtained by the use of two or more rods in parallel with adequate separation between them. See Fig. 8.

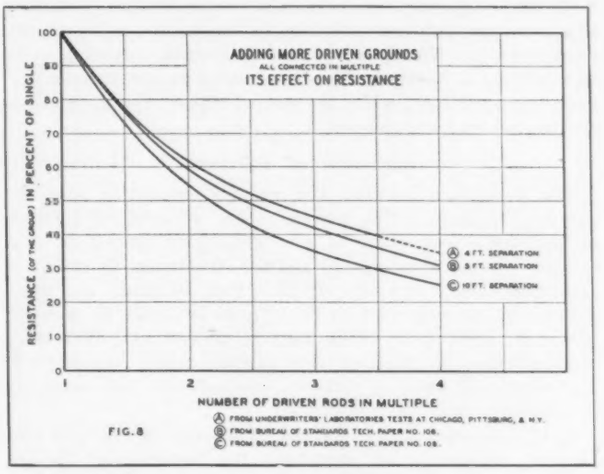

ADDING MORE DRIVEN GROUNDS
ALL CONNECTED IN MULTIPLE
ITS EFFECT ON RESISTANCE
RESISTANCE (OF THE GROUP) IN PERCENT OF SINGLE
NUMBER OF DRIVEN RODS IN MULTIPLE
FIG. 8

*Fig. 8. Effect on resistance of adding more driven rods, connected in multiple.*

Approximately 40 per cent reduction in resistance is obtainable by driving and connecting in multiple a second driven ground separated about 6 ft. from the first one. Additional rods, will decrease the resistance almost in proportion to the number used.

5. *Conductivity of soil surrounding the rod* may be increased by soil treatment, thereby reducing the resistance of the grounds.

This can be accomplished by chemical treatment of the soil, which in high resistance soils, often results in reduction of 50 to 75 per cent. See Fig. 5. The disadvantage of soil treatment is that the chemical is gradually carried away by the water flowing through the soil and must be renewed after a period of time. However, where testing and regular inspection of grounds is possible, this method is quite satisfactory. Tests made recently show that chemical applications are beneficial for at least one or two years, and while the

chemical may be partially carried away by water, there appears to be some permanent improvement, especially after several renewals of the chemicals.

Many different salts and chemicals have been used with varying results. Experiments are now being conducted with magnesium sulphate as a treating medium. A solution of this salt has a conductivity comparable with the chemicals or salts more commonly used. When used in connection with different types of soil, less corrosive action was found with the use of this salt than when others were used.

One method of treating the soil, which has been commonly used, is to dig a hole about the ground rod approximately 2 ft. in radius and 1 ft. deep. The treating medium is placed in this hole, and flooded with water, after which the earth is backfilled. This method places the chemical directly against the rod and the chance for corrosive action is greater, due to the alternate drying out and soaking due to the weather. Another method is to dig a shallow trench around the rod, but about a foot away. The chemical is placed in this trench, the ground soaked and the trench backfilled. This prevents the chemical from coming directly in contact with the rod and reaches the rod only by filtering through the earth.

*Buried Cones and Plates —*

This subcommittee has devoted no time to the study of cones, plates, or other buried electrodes. Their principal application appears to be for grounds at substations and other localities where there is sufficient room for excavation and where the cost of this type of ground is justified. There have been a number of reports and articles written on this subject, one interesting article by E. R. Stauffacher appearing in the Electrical World March 7, 1925, and describing tests made by the Southern California Edison Company using copper sulphate solution in connection with copper ground plates. Nearly all of the California operating companies bury a number of ground plates at substations and generating stations, while the use of water pipe grounds in conjunction is quite general.

## Methods of Testing

The resistance between the ground connection and the surrounding ground has generally been accepted as a measure of the effectiveness of any grounding system in preventing excessive voltage to nearby structures. In order to determine this, it is necessary that tests be made, and most authorities recommend that these tests be made at periodic intervals. There are various methods of test. All have their disadvantages, but most of them are reasonably satisfactory. The results obtained by different methods over the same set of conditions may vary somewhat.

L. C. Edwards of the Bureau of Tests, Pacific Gas and Electric Company, has prepared for presentation before this committee an analysis of the different methods of test in which their relative accuracies are compared. This analysis was also presented before the meter committee and has been included in considerable detail in their annual report. To avoid duplication, it has been omitted from this report.

## Observed Values

Testing of ground resistance has been carried on actively in different parts of the state for the past two years and special tests have been made in those areas where the common neutral system has been placed in operation.

Recognizing that there is a wide seasonal variation of values of resistance due to moisture content, tests were made in the San Francisco and East Bay areas and in the Stockton area at the end of the spring wet season in 1929 and repeated at the end of the 1929 summer dry season. A summary of the results of these tests, together with the results of tests in other localities in California, representing extreme differences in soil conditions, etc., are included in this report. The general conclusions to be drawn are consistent with the conclusions made in another portion of this report. This indicates that after due study and consideration of all the factors involved in the grounding problem and after due consideration of all variables, the results obtained are consistant to a reasonable degree with the predictions as made. For example, it was expected that the resistance found at the end of a dry season would be substantially higher than those found for the same locality at the end of a wet season, and it was also expected that the resistance would be higher in the valley than close to the bay. These expectations were borne out by the tests.

The most recent survey of grounds involved in the 4-kv. common neutral system was made at Chico during November, 1930. Tests were made at various points on the grid to determine the grid resistance to ground and individual grounds were isolated by cutting the ground wire at the surface of the pole. Tests were made at 46 different locations in the common neutral system. The soil was very dry, as the tests were made at approximately the end of the dry season, there having been but two rains within three weeks of the time of the test. There was moisture for approximately a foot below the surface which probably had little effect in lowering the ground resistance. These values are mentioned here because this locality can be regarded as one of unfavorable grounding conditions and if satisfactory values of conductivity can be obtained here, we believe it should be looked upon as an indication of the practicability and safety of the common neutral system, even under unfavorable conditions.

The maximum value of the grid resistance was found to be 3.5 ohms, which was the maximum as specified by the Railroad Commission at the time the installation was made. The minimum is 0.4 ohms and the average of 46 locations is 1.21 ohms. The average resistance of the isolated copperweld grounds, two in multiple, taken over 30 different locations, was found to be 38.8 ohms. The maximum value for two rods in multiple is 165 ohms and the minimum 6.5 ohms. The average resistance of three private water systems is 3.03 ohms; the city water system average for six locations is 1.11 ohms; the gas system average for six locations is 1.19 ohms and the railway ground on the Sacramento Northern Railway on one test showed 0.9 ohm.

The following table shows variations of ground resistance values obtained in different localities in California, in connection with the common neutral survey:

TABLE I.

| | Number of Electrodes | | Resistance of Ohms of | | | |
|---|---|---|---|---|---|---|
| | | | Rod Grounds | | Water Pipe Grounds | |
| Territory | Rod | Water | Max. | Min. | Max. | Min. |
| Alhambra | 136 | 80 | 23.0 | .15 | .90 | .06 |
| Sub. Area No. 2—L. A. | 550 | 155 | 55.0 | 2.00 | .14 | .02 |
| Richmond | 96 | ... | 11.2 | 2.30 | ... | ... |
| Long Beach | 414 | 4 | 320.0 | .53 | ... | .20 |
| Sub. Area No. 14—L. A. | 235 | 148 | 15.0 | 1.90 | .90 | .07 |
| Sub. Area No. 1—L. A. | 172 | 276 | 149.0 | .98 | .48 | .02 |
| Redondo | 248 | 28 | 16.0 | 1.82 | .37 | .32 |
| Ventura | 22 | 6 | 24.0 | 9.00 | .80 | .20 |
| Laguna Beach | 185 | 26 | 70.0 | 1.58 | .08 | .06 |
| Palm Springs | 14 | 45 | 635.0 | 150.00 | 150.00 | .05 |
| Palm Springs | (Combination) | 65 | Max. 170.0 | | Min. 4.0 | |

## Conclusions

There is no doubt as to the value and the necessity of adequate grounds. It is likewise obvious that the condition of maximum safety is obtained when we have a multiplicity of grounds connected to the same copper grounding grid of suitable conductivity. It is likewise apparent that ground resistance values will vary within a large range due to locations, seasons of the year, type of ground electrode used and the severity and class of service to which subjected.

With these facts before us, it would appear that construction economics dictate that an endeavor should be made to

COMPARISON OF RESISTANCES AS MEASURED AT THE END OF A WET AND DRY SEASON

| | End of wet season, April to May, 1929 | End of dry season October, 1929 |
|---|---|---|
| Total number of grounds measured | 143 | 143 |
| Average resistance of all grounds (ohms) | 51.1 | 76.8 |
| Per cent increase in average resistance of all grounds | | 50% |
| Number of grounds that increased in resistance | | 111 |
| Number of grounds that decreased in resistance | | 32 |
| Number of grounds below 25 ohms | 75 | 60 |
| Per cent of grounds below 25 ohms | 52 | 42 |
| Number of pipe grounds measured | 91 | 92 |
| Average resistance of pipe grounds (ohms) | 55.4 | 79.6 |
| Per cent increase in average resistance of pipe grounds | | 43.7% |
| Number of copperweld grounds measured | 52 | 51 |
| Average resistance of copperweld grounds (ohms) | 42.1 | 69 |
| Per cent increase in average resistance of copperweld grounds | | 64% |
| The different sections are segregated as follows: | | |
| *East Bay—Albany, El Cerrito and Richmond* | | |
| Number of grounds measured | | 71 |
| Average resistance of all grounds (ohms) | 26.4 | 43.4 |
| Per cent increase in resistance at end of dry season | | 64.4% |
| *San Francisco* | | |
| Number of grounds measured | | 38 |
| Average resistance of all grounds (ohms) | 91 | 115 |
| Percent increase in resistance at end of dry season | | 26.4% |
| *Livermore, Pleasanton, Walnut Creek, Orinda* | | |
| Number of grounds measured | | 16 |
| Average resistance of all grounds (ohms) | 82.2 | 148 |
| Percent increase in resistance at end of dry season | | 80% |
| *Stockton, Manteca, Lodi* | | |
| Number of grounds measured | | 18 |
| Average resistance of all grounds (ohms) | 35.8 | 59.6 |
| Percent increase in resistance at end of dry season | | 66.5% |

classify grounds. In this classification the following features are important:

1. *Dependability of Ground Connections* —

This requires a permanent, maximum ground resistance value throughout the expected life of the electrode.

2. *Area in which located* —

Where the conducting earth surfaces have a known high resistance value, the protective ground should be permitted varying resistance values below this constant.

3. *Circuit Classification* —

Inherent characteristics of the circuit or circuits involved and the class of equipment to which attached should be given due recognition and evaluated.

4. *Multiplicity of Ground Connections* —

In general, it may be assumed that the effective, combined resistances of parallel grounds are approximately inversely proportional to the number; the resultant division of current imposes less severe demands on the individual electrode. This is particularly true in network systems, and the laws of probability will have a direct bearing in setting up values of resistance in all areas of this type.

5. *Types of Ground Electrodes* —

The most satisfactory type is the metallic water piping system, its dependability not being questioned. Therefore, system grounding requirements employing this type of grid are entitled to modifications, depending upon the particular water system.

The driven pipe or rod is limited in application, its characteristics and limitations having been covered in some detail in this report. The limiting factors can probably be treated under construction specifications.

6. *Specifications* —

Construction specifications should be general in scope and greater attention given to the purpose for which the ground is installed and the results expected of it. The means to be used should be decided in accordance with the situation surrounding the individual case. This requires that the limiting value of at least the most important physical characteristics be designated.

Since soil conditions in certain localities in the state practically eliminate the possibility of adequate grounding of circuits and equipment, the supplementary method, such as isolation of equipment and additional insulation of ground wires, should be given consideration. This latter is suggested as a means of averting any danger due to a difference in potential between ground wires and the ground itself.

In addition to the features mentioned above, attention must be given to the capacity of a grounding connection to dissipate energy. An additional testing should be carried on where resistance values are found to be high and where the possible attending current flow is of considerable magnitude.

The use of the common primary and secondary grounded neutral systems has necessitated that greater attention and study be given the matter of grounding. The possibility of harmful voltages occurring is somewhat increased, unless a continuous low resistance ground grid is at all times available. The practical solution includes multiplicity of grounds and interconnected networks and return paths, thus relieving the duty on each individual ground.

It is suggested that the utilities keep a complete record of representative grounds under varying conditions of soil, moisture, etc. and over different intervals of time. This information, supplementing the data which your subcommittee has collected and included in this report, should be made available from time to time as a basis of more definite information and as a guide to construction practices.

As stated in a previous preliminary report, this subcommittee had no intention of attempting to cover the entire subject of grounding during the current year. We have presented herein the results and conclusions of our year's study on the principles and limitations involved in certain types of grounds, with particular reference to those used in connection with overhead electric systems. We believe that the facts and findings set forth herein may be of value to the industry and may be used in preparing the way for a more complete understanding of the particular phases of this subject with which we have been dealing. We believe that with this information it will now be possible and practicable to proceed with the preparation of suitable and definite standards for grounding, properly classified as to duty, type and location. These standards should, for the time being, be considered as tentative, subject to revision from time to time, if further information, study and tests indicate the advisability of such procedure.

We feel there has been some misapprehension, both within the industry and without, as to the dangers resulting from the interconnection of electrical and other metallic systems. We believe that it is not only desirable, but necessary, for interested members of the central station industry to carry on a program of education in order that the true facts of the situation may be known and groundless fears dissipated. The objection of the water supply people to the grounding of electrical supply systems to water pipes is a striking example of this point. We believe that the investigation carried on by the N.E.L.A. is particularly timely. We recommend that central station engineers adopt the suggestion of N.E.L.A. headquarters in its recent report, in order that the water supply authorities may learn the true facts of the grounding situation and be reassured as to their fears.

# *Line Conductors**

*The personnel of the subcommittee on line conductors was divided into groups and subjects assigned to each for study and report. This report includes data compiled on the following subjects:*

*Distribution Span Lengths and Stringing Tensions.*

*Bare vs. Weatherproof Conductors for Distribution.*

*Tree Wire and Aerial Lead Covered Cable.*

## *Distribution Span Lengths and Stringing Tensions*[2]

*The following report on span lengths and stringing tensions has been treated particularly as regards the requirements for guying under General Order 64-A of the California Railroad Commission.*

SHORTLY after the adoption of General Order 64-A, the Railroad Commission requested the operating utilities to compile, on the basis of their standard practice as to span lengths and conductor sags, a table of guying methods in conformity with the requirements of the General Order. It was found by the majority of utilities that, particularly where the larger sized conductors were involved, the guying requirements were considerably in excess of those formerly in general use. Upon application to the commission, some deviation below the computed maximum tensions was allowed for weather-proof insulated conductors of No. 1/0 and larger. Even with such reduction, however, the utilities are faced with an added investment in guying in order to meet the state law requirements.

Guying costs form a considerable portion of the distribution investment in poles and fixtures, especially on heavily loaded leads, and, since few if any failures have resulted under former methods, its seems unnecessary to increase such investment. In addition to the economic side of the problem, is the practical difficulty encountered in installation of an increased number of guys and properly maintaining tension in them after installation.

### Difficulties in Computation

The main difficulty in determining guying requirements is in establishing a proper method of computing actual guy tensions as installed. The only practicable method at present seems to be that in use in the General Order: that is, the pole below the point of guy attachment is considered merely as a strut and the whole system of forces assumed rigid. To allow for the actual flexibility of the system and to proportion to the pole its proper stress, involves numerous variables, as: soil type and condition, anchor type, anchorage depth, etc. Some of the utilities have attempted to determine by field tests the effect of these variables, but to date the results have been too scattered and inconsistent to form a basis for any computation method to replace that now in use.

### Rural Distribution

Inquiries sent to distribution engineers in a number of the operating utilities over the state indicate a close uniformity in present practice as to span lengths and stringing tensions. Those utilities reporting have little distribution in heavy loading districts and the replies were confined to light loading areas.

In rural distribution, the general practice indicates the use of 250 to 300-ft. spans in new extensions. If load develops and larger sized conductors are required, poles are inter-set in the span. Since the pole leads are generally lightly loaded and conductor sizes small, little difficulty is encountered in meeting the guy requirements of the order. All the utilities use bare copper for over 4,600-volt distribution and a good many are extending its use to the lower voltage in their rural areas.

### Urban Distribution

In urban distribution, the average span length is about 135 to 160 ft. The span length in such distribution is determined more by considerations such as lot subdivision, length of blocks, width of streets, and by joint pole use with communication and transportation utilities, than by theoretical considerations. Those companies using T.B.W.P. conductors report an unloaded sag at 60 degrees F., 150-ft. span, of about 18 in. This sag results in a maximum tension of from 18,000 lb. per sq. in. for No. 6 to 13,000 lb. per sq. in. for No. 4/0, all values being well below the maximum allowed by the General Order. One company reports the general use of medium hard drawn bare copper in both rural and urban areas, except where local ordinance prohibits such use. The unloaded stringing tension is given as 12,000 lb. per sq. in. at 70 degrees F, which, at maximum loading, results in a slightly higher tension than for general practice with T.B.W.P. wire.

All the companies report that the wire is "sagged in" by sighting, a method approaching accuracy only as the construction foremen realize the importance of close conformity to the utilities' standard.

### Changes Expensive

To reduce conductor tension, and thus the guying requirements, would necessitate changes in the present construction practice which we believe would be uneconomical.

Maintaining the present stringing sag and shortening span lengths would reduce the tension as the square of the span ratio, but would involve considerable investment in poles, crossarms and insulators. Furthermore, it would in many places prove impractical for actual geographical conditions. To increase conductor sag with the span lengths now in use would involve greater conductor spacing if equivalent reliability to present practice is maintained. Greater conductor spacing, particularly for those companies now using combination primary and secondary arms, would necessitate increased pole height and investment.

The subject of bare copper wire for distribution is being fully treated by another subcommittee. However, as to guying requirements, the stringing tensions for bare wire, established through the experience of the company reporting its use, would indicate that the guying problem will not be lessened by the adoption of such construction.

### Guy Wire of Greater Tensile Strength

The solution of some of the guying problems may be met by the increased use of guy wire of greater tensile strength than the ordinary steel strand. Each utility, by making a study of its problems, may find not only economy in the adoption of such practice, but also some relief in the reduced number of guys required.

The following table of cost and strength ratio of guy wire indicates the possibility of considerable economy with the use of Siemens-Martin or high strength steel as compared to ordinary steel strand.

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* Report of subcommittee on line conductors, overhead systems committee, Engineering Section. W. E. Row, chairman. C. E. Crilly, F. E. Dellinger, O. W. Holden, J. F. Hodges, C. E. Heath, Walter Hayes, A. M. Jepperson, W. P. Loper, J. B. Moorehead, R. W. Muller, C. T. Mess, A. W. Pride, Paul Suransky, D. D. Smalley, R. M. Spencer, L. B. Smith, A. L. Williams, C. C. Wilson.

[2] Written for subcommittee on line conductors, overhead systems committee, Engineering Section, by A. L. Williams, W. P. Loper, C. T. Mess, J. B. Moorehead, R. M. Spencer.

TABLE I

Cost and Strength Ratios for Guy Wire

| Guy Wire Size (inches) | Ordinary Cost Ratio | Ordinary Strength Ratio | Siemens-Marten Cost Ratio | Siemens-Marten Strength Ratio | High Strength Steel Cost Ratio | High Strength Steel Strength Ratio |
|---|---|---|---|---|---|---|
| 1/4 | 1.0 | 1.0 | 1.33 | 1.60 | .... | 2.68 |
| 5/16 | 1.0 | 1.0 | 1.38 | 1.52 | 1.72 | 2.53 |
| 3/8 | 1.0 | 1.0 | 1.30 | 1.60 | 1.71 | 2.70 |
| 7/16 | 1.0 | 1.0 | 1.33 | 1.58 | 1.81 | 2.63 |
| 1/2 | 1.0 | 1.0 | 1.33 | 1.48 | 1.79 | 2.44 |

The cost ratios in the above table are based on current (November, 1930) prices for lots of 10,000 ft. The strength ratios are based on Table 22, Appendix B, of General Order 64-A. The cost ratio is for the wire only and does not include any make-up, insulators, anchors or other hardware. In general, the inclusion of these items will result in an even greater economy in favor of the higher strength wire.

## *Bare vs. Weatherproof Conductor For Distribution*[2]

*Considerations of safety and cost both favor the adoption of bare wire for all overhead lines.*

IN MAKING this study, the committee was concerned more with the securing of data regarding the value of covering on wire as opposed to bare wire, than with the preparation of comparative tables of sag and tension stresses and other engineering information.

### General Considerations

The use of weatherproof wire for overhead lines operating at voltages of 4 kv. and less, has been generally practiced for many years. In the past few years, however, certain operating companies have been experimenting with the use of bare wire for lower voltages with very satisfactory results. A report made to the National Electric Light Association states that one of the largest power companies in the south began using bare wire for all overhead distributing systems in 1923. This practice has been adopted in 189 towns and the results have justified the change. One small company in California has used bare conductor for all overhead system, except services, since 1919. The change was made in this case because of unsatisfactory results obtained from the use of weatherproof wire. If the use of weatherproof wire had been continued throughout this period, at least one replacement would have been necessary, if any protection was to have been maintained.

These installations have been in use long enough to permit us to draw some rather definite conclusions regarding the advantages of bare wire over weatherproof wire. No evidence has been found to indicate that city ordinaces requiring the use of covered wire are based on any definite data, but rather are included in the city laws as a matter of habit. These ordinances are very rarely enforced.

### Safety

1. *To the General Public—*

It is generally agreed that any covered wire gives a false impression of safety and most people feel that any covered wire is insulated. The movement which seems to be under way to educate the public not to handle any wire, covered or not, should be encouraged, but it is doubtful whether this educational work can possibly reach everyone who might have an opportunity to come in contact with a fallen conductor. The general fear of a bare wire will in most cases prevent anyone from deliberately handling it, whereas even an instructed person will "take a chance," to clear the way of a covered wire. It has been found that there are fewer failures of bare conductor than of weatherproof, for when a bare conductor does fall, there is a better chance that it will open the feeder circuit breaker than would be the case if it were covered. Contacts in the span will burn down weatherproof wire more often than bare wire, as contacts between two phases of bare wire will invariably cause the feeder circuit breaker to open.

There seems to be very little difference in the responsibility of the company, whether bare or covered wire is used, because in any event the company is usually held responsible. Various reports from different sections of the country state that there have been fewer accidents to the general public from fallen wires where bare conductor is used, than was the case where weatherproof wire was used. This may be due to a certain extent to the fact that there are fewer failures of bare wire, but the results are gratifying, regardless of cause.

2. *To Power Company Workmen—*

Most operating companies incorporate in their rule books a statement to the effect that no confidence is to be placed in weatherproof covering, when working on energized lines. Rubber gloves, blankets and live-line maintenance are generally used, whether the conductor is covered or not. Regardless of rules and regardless of equipment furnished for workmen who are handling live circuits, it is obvious that the employee will have much more respect for the bare conductor than for the covered one and will conduct himself accordingly.

When it becomes necessary to replace the conductors in an energized line operating at voltages up to 4 kv., weatherproof wire offers considerable advantage, because the new conductors can be strung with greater safety. The new wire can be pulled in, either on the same arm which carries the circuit being replaced or on the secondary arm below the existing current, whence it can be transferred to its proper position and the old circuit pulled out. This cannot be done where bare conductor is used, unless the existing circuit is spread horizontally or raised above the arm a sufficient distance to eliminate the possibility of contact between the old energized circuit and the new conductor which is being installed. It should be noted that in case the weatherproof line being replaced has been in service for a great number of years, extra precaution should be taken and the workmen should not place too much confidence in the value of the covering on the wire. Such work should not be done in wet weather, where the aging of the line may indicate badly deteriorated covering.

Tests of various samples of triple-braid weatherproof wire from various areas have been made. These tests were made with a standard 35-kv. insulation test set. The immersion test was made by putting the wire samples in a metal lined tray filled with water from a city system and one end of the test equipment was connected to the tray and the other to the wire to be tested. The dry tests were made by wrapping the sample with tinfoil and connecting one side of the transformer to the tinfoil and the other side to the conductor. Most of the tests were made with wire which had been in use in coast territory. One statement was received to the effect that weatherproof wire used in the interior did not deteriorate so rapidly and its use was defended for that reason. Tests were made on samples of such wire which had been in service for various lengths of time and it was found that although the general appearance of the wire was good, its insulating properties, when immersed in water, were worse than for the wire which had been in service in the coast area. This is evidently due to the fact that the hot, dry climate of the interior had thoroughly baked out all of the impregnating compound and

[2] Written for line conductors subcommittee, overhead systems committee, Engineering Section.

had left the covering very porous. The results of these tests are shown in Table I.

TABLE I

| Wire Size | Age Years | Condition | Immersion | Dry |
|---|---|---|---|---|
| Samples from Coast Area— | | | | |
| No. 2 | New | | 2600 | 3100 |
| No. 4 | New | | 2800 | 3400 |
| No. 2 | 1 | Very good | 2100 | 3000 |
| No. 2 | 2 | Braids dry—some white threads | 300 | 900 |
| No. 2 | 4 | Braids separated—brittle | 0 | 0 |
| No. 4 | 1 | Good | 500 | 1000 |
| No. 4 | 3 | Braids dry and brittle | 0 | 0 |
| Following samples from Interior Valley Area— | | | | |
| No. 2 | 2 | Braid hard, dry, white threads in outer braid | 0 | 700 |
| No. 2 | 4 | Braid hard, dry, outer braid white andbrittle | 0 | 0 |

### Costs

1. *Construction—*

It has been found that from 15 to 25 per cent saving can be effected by using bare conductor rather than weatherproof wire, due to the lesser cost of the wire, longer spans, reduced cost of transportation and handling. Spans in excess of 200 ft. are not recommended for weatherproof wire. It is true that in urban construction it is rarely possible to exceed 200-ft. spans, in any event, due to service requirements, joint pole conditions, etc., but very material savings can be effected in rural areas by using longer spans and bare wire. Less sag is necessary for bare wire than for weatherproof conductors, because there is less weight involved and there is greater strength. Bare wire can usually be strung with approximately 65 per cent of the sag required for weatherproof. This means that no greater horizontal spacings are required for bare wire than for weatherproof, as the lesser sag decreases the possibility of the conductors swinging together. There is also less area exposed to wind loading with bare wire than with weatherproof wire. Table 2 gives a comparison of weights and diameters to illustrate this point.

TABLE II
Comparison of Weights and Diameters

| Size | T. B. W. P. Wire Weight Per 1000 Ft. | T. B. W. P. Wire Diameter in Inches | Bare Copper Wire Weight Per 1000 Ft. | Bare Copper Wire Diameter in Inches |
|---|---|---|---|---|
| 4/0 Stranded | 800 | 0.810 | 653 | 0.528 |
| 2/0 Stranded | 522 | 0.680 | 411 | 0.438 |
| 2 Stranded | 270 | 0.500 | 205 | 0.292 |
| 4 Solid | 164 | 0.370 | 126 | 0.204 |
| 6 Solid | 112 | 0.330 | 80 | 0.162 |

One California company reports that over a period of three years the difference in cost of weatherproof wire actually used as against bare wire, amounted to $209,000. This figure includes wire used for services where no change could be made, but the use of bare conductor would have resulted in saving on poles, crossarms, hardware, insulators and labor, which would more than offset this inclusion.

2. *Operating Costs—*

It is quite evident that maintenance of bare conductors will be very much less than of weatherproof wire. It has been found that most companies figure on pulling slack on weatherproof wire periodically, whereas this is not necessary on a properly constructed line using bare conductor. The greatest maintenance cost is in replacement, because if it is advisable to use covered wire at all, it is certainly necessary that it be maintained in good order. If this rule were rigidly followed, it would mean that in many cases the wire would have to be renewed after two years of service. Of course this is not done and it is usually allowed to go until the covering is so badly worn that it hangs in long festoons, when replacement is carried out more because of the appearance of the line than for any other reason. Bare wire has unlimited life and a high salvage value. It is safe to say that weatherproof wire which has been in service for five years or more, cannot be salvaged as useful material.

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## *Tree Wire and Aerial Lead Covered Cable*[2]

*This report covers the practice and experience relative to tree wire and aerial lead covered cable as reported by the various companies. It is divided into seven parts covering tree wire, aerial lead covered cable, trenchlay cable, economics of eliminating tree interference, heights and growth of trees, recommendations and conclusion.*

THIS report is the result of replies received from 54 companies throughout the United States to a questionnaire on tree wire and aerial lead-covered cables. It contains the practices and experiences of these companies and much other data, such as statistics on performance of each type of construction, that should be of value to member companies of the P.C.E.A. Recommendations for future study and standardization are given.

Each year we find it becoming more difficult for the public utilities to obtain permission for tree trimming in order to insure continuity of service from their electric lines. Thus, the operating departments of the utilities are faced with the problem of giving uninterrupted service under increasing difficulties, and at a time when utility executives are insisting that the cost of distribution per customer be reduced.

### Methods of Elimination

There are several methods of eliminating tree interference. Some utilities have contracted with tree surgeons to obtain the required trimming permits and do all necessary tree trimming on their systems. The work is done by experts and should insure the maintenance of the natural shape and beauty of the trees. Other utilities have adopted a policy of setting poles of sufficient height to permit the conductors to be carried over the tops of trees. The difficulty with this system is that it is often impossible to determine the ultimate height of the trees to be cleared and if their heights are underestimated, it will result in the setting of poles that are too short and in later tree interference. Other utilities are using tree wire and aerial lead-covered cables freely and going through the trees, with supporting poles as short as possible. Still other utilities reroute their lines, if possible, when tree interference is encountered, or use a combination of the foregoing methods.

### Questionnaire on Tree Wire

Among the various methods of eliminating tree interference, it appears that tree wire and aerial lead-covered cable have a prominent place. The overhead systems committee, recognizing this fact, chose the subject of "Tree Wire and Aerial Lead-covered Cable" as one of its studies for this year. A casual investigation by the writer indicated that the amount of tree wire and aerial lead-covered cable in use in the P.C.E.A. territory was rather limited and not in use for sufficient length of time to determine its value; hence it was decided to send a questionnaire covering this subject to other companies throughout the United States, as well as member companies of the P.C.E.A., to determine the results of their experiences and practices.

This questionnaire was sent to 73 companies scattered throughout the country. To date 54 replies have been received. A compilation of these replies shows that these companies have installed on their systems about 51,100,000 ft. of tree wire and almost 647,000 ft. of aerial lead-covered cable.

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[2] Written for line conductors subcommittee, overhead systems committee, Engineering Section, by Paul Suransky.

### Definitions

Definitions of certain terms used in the report are:

*Tree Wire*—A wire usually insulated by a layer of rubber of sufficient thickness to insulate for the voltage used and covered by some abrasion resisting material.

*Open Construction*—A type of construction in which the conductors are usually spread out horizontally on a crossarm and each conductor is supported by an insulator.

*Cable Ring Construction*—A type of construction in which more than one conductor, grouped either under one common sheath or singly, are suspended in cable rings from a messenger.

*Aerial Lead-covered Cable*—A lead-covered cable installed with cable ring construction.

*Trench Lay Cable*—A cable which is installed directly in the ground.

## *Part I—Tree Wire*

### Where Used and Its Advantages

1. Where it is impossible to clear trees with high poles.
2. Where investigation shows it to be more economical than the installation of high poles.
3. When the cost of yearly trimming of trees more than offsets the cost of carrying the added investment of tree wire.
4. Where unable to obtain permission to trim trees.
5. Where trimming would hurt the appearance of the trees.
6. Where there is danger of limbs or branches being blown across primary lines.
7. Alongside of buildings where satisfactory clearances cannot be obtained.
8. For service wires through heavy growth trees.
9. Vertical runs from primary to transformer.
10. Sometimes used in crossing over communication lines.
11. Where future growth of trees might cause interference to circuits.
12. Where additional safety is desired.
13. For telephone circuits consisting of a limited number of conductors which do not warrant aerial lead-covered cable.
14. Where conductors pass through, over or closely adjacent to trees, which may not be trimmed for satisfactory clearances to distribution lines.
15. Where it is difficult to obtain trimming permits.
16. As a means to insure continuity of service.
17. When the cost of rights-of-way are exhorbitant.
18. For the elimination of radio interference due to arcing of wires in trees.
19. Properly installed, it can be depended upon to effect a reduction in outside plant troubles with a corresponding improvement in service.
20. Better public relations result due to elimination of a large amount of tree trimming and to the reduction of outages to service.
21. When it is desired to replace existing bare wires with larger bare wires without an interruption to service and where extraordinarily hazardous conditions exist, tree wire can be strung in temporarily and energized and the existing conductor de-energized; the wire to be replaced can then be removed and the larger wire strung with safety to the workmen and no resulting outage to service.

### Sizes, Weights, Voltages and Specifications

Tree wire can be obtained in standard sizes ranging from No. 10 A.W.G. to No. 4/0 A.W.G. and for voltages from 600 volts, working pressure, to 7,500 volts, working pressure. Recently one manufacturer has placed a tree wire on the market with a rating of 13,200 volts, working pressure.

Table I will give an idea of the relative weights of tree wire compared to weatherproof wire.

Each manufacturer has his own voltage classification for tree wire. For example, one manufacturer's ratings in volts working pressure are 600, 1,500, 3,000, 4,000, 5,000, and 7,000, while another manufacturer's ratings are 1,500, 2,500, 3,500, 5,000, and 7,500, and still another manufacturer does not rate his tree wire in volts, working pressure, but in thickness of insulation. This makes it rather difficult in making a comparative analysis of performance of the various manufacturer's products. It would be desirable to adopt certain voltages as standard and allow each manufacturer to insulate his product to meet the test requirements for each particular voltage. Adoption of such standard voltages would permit comparisons of performance and of cost by the utilities.

TABLE I

| Size A.W.G. | Approx. Net Weight in Pounds per 1,000 Feet Tree Wire 600 Volts Working Pressure | Tree Wire 7500 Volts Working Pressure | W. P. Wire (Triple Braid) |
|---|---|---|---|
| 8 | 155 | 420 | 75 |
| 6 | 210 | 470 | 112 |
| 4 | 265 | 555 | 164 |
| 2 | 360 | 675 | 260 |
| | 1500 Volts Working Pressure | | |
| 1 | 480 | 760 | 316 |
| 0 | 550 | 865 | 407 |
| 00 | 660 | 990 | 502 |
| 000 | 785 | 1150 | 629 |
| 0000 | 940 | 1320 | 767 |

Not only do the manufacturer's voltages differ from one another, but the engineers of the various utilities are not agreed among themselves as to the proper rating to be used on a given operating voltage. This is exemplified by the following data compiled from the questionnaire, which was sent to the various utilities.

TABLE II

| Circuit Voltage | Connection | Rating of Tree Wire Used |
|---|---|---|
| 115/230 volt | | 600 volt; 3.5 kv. |
| 2.3 kv. | delta | 2.5 kv., 3 kv., 5 kv., 7.5 kv. |
| 3.6 kv. to 4 kv. | star | 2.5 kv., 3 kv., 3.5 kv., 4 kv., 5 kv., 7.5 kv., 10 kv. |
| 4.6 kv. to 5 kv. | delta | 3.5 kv., 5 kv. |
| 6.6 kv. to 6.9 kv. | delta | 7 kv., 7.5 kv., 10 kv. |
| 11.5 kv. | star | 7 kv., 7.5 kv. |
| Street Light Circuits, 5 kv. | series | 2.3 kv., 5 kv. |
| Telephone | | 600 volt |

The above data indicate that the utility engineers can also well afford to give some attention to this subject as there should not be such a variance in identical circuits.

Of the companies using tree wire, 42 replied that they have no specifications of their own, but relied entirely upon the manufacturers' specifications, while three companies have their own specifications. Eleven different makes of tree wire were reported; this number no doubt in the future will be reduced considerably, due to the recent consolidation of the various cable manufacturers.

### Laboratory Tests

There has not been sufficient time to delve into the various laboratory tests used for determining the relative merits and performance of the various makes of tree wire. One company, however, reported that before adopting any tree wire as a standard for its system, the tree wire was first subjected to a wear test, a dielectric test, and a weathering test.

*The Wear Test*—The reciprocating motion of a power hack saw frame is used as a substitute for the wearing or rubbing motion between the tree wire and a tree limb. The wire is clamped in the usual place in the frame for material. In place of the hack saw, a piece of maple wood is substituted. The wood is of uniform width (⅜ in.). The stroke of reciprocating motion is 5¼ in., with a weight of 20 lb. at a lever arm of 18 in.. bearing against the wire at the point of wearing. A record of the number of strokes required to wear through the insulation on the wire is obtained by means of a revolution counter.

*The Dielectric Test*—This test is made with the wire immersed in a water bath, the potential being between the conductor and the bath.

*The Weathering Test*—The ends of a 1-ft. piece are sealed with sealing wax to prevent moisture from entering the layers of insulation. The piece is then hung on the roof of the laboratory building in a position in which it will be exposed to a maximum of sunlight, wind and rain. Periodically the piece is inspected to determine the quality of the sample under test.

The company using the above tests has found them to be satisfactory and of considerable value in aiding its engineers in arriving at what makes of tree wire shall be used on its system.

### Tree Wire—Open Construction

For this type of construction tree wire is preferable in all cases, as it is the most economical type of construction. It can be used in practically all instances except where tree growth is too dense. Typical installations of this type of construction are shown in Figs. 1 to 4, inclusive.

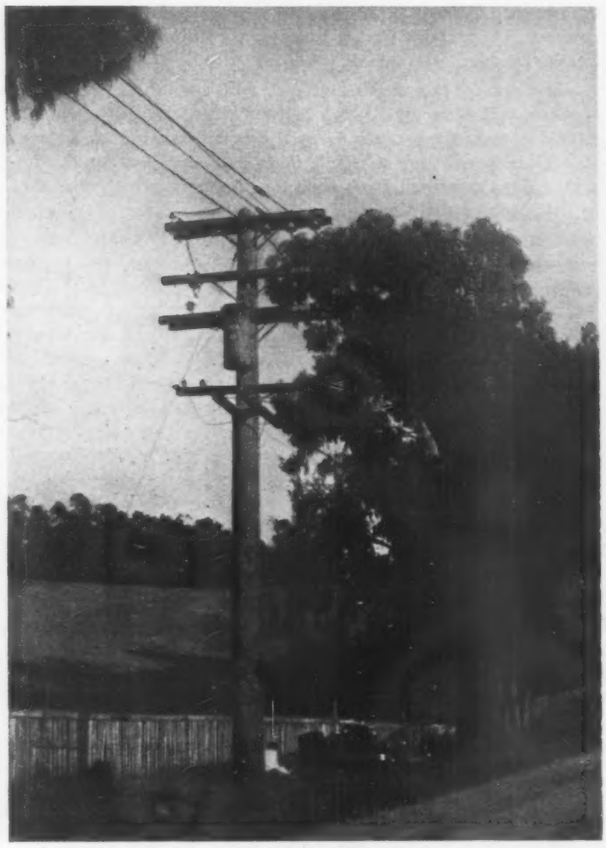


*Fig. 1. No. 6 11-kv. installation; note line splice and tap to transformer.*

*Fig. 2. No. 6 tree wire on 3-phase wires and 1-series streetlight wire, with breaker cut in latter for lamp loop.*

*Distribution and Performance—*

The item of greatest concern and interest to a company considering the use of tree wire is what kind of service can be expected. The following statistics have been compiled to give an idea of past performance.

Total for 29 companies reporting:

| | Amount In Miles | Failures Per 100 Miles | Failures Per 100 Miles Per Year |
|---|---|---|---|
| Installed 5 years or over | 227.7 | 8.35 | 1.67 |
| Installed less than 5 years | 3,118.4 | 1.22 | 0.41 |
| Totals | 3,346.1 | 1.71 | 0.546 |

The failures per 100 miles mentioned in the statistics cover the total failures up to and including November, 1930. Data submitted by the various companies was such that it is impossible to determine the actual failures per 100 miles per year, which is the preferable unit for comparison of performance; however, for all the tree wire reported as installed 5 years or over, a very conservative estimate of the failures per 100 miles per year was reached by dividing the failures per 100 miles by 5. Likewise for tree wire reported as installed for less than 5 years, an average might be reached by dividing the failures per 100 miles by 3. These figures should result in sufficient accuracy to give an idea of what performance can be expected from tree wire with open type of construction.

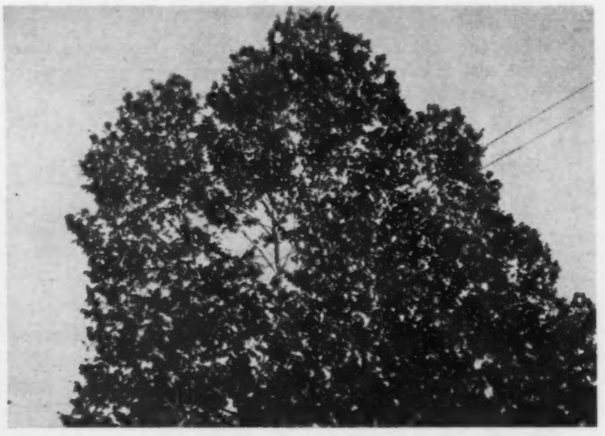


*Fig. 3. Tree wire inserted in a two-wire service.*

In passing, it is of interest to state that one company reported that it estimated about 30,000,000 ft. of tree wire on its 4-kv. star distribution circuits. Although this company could not give definite figures as to its performance, it made the statement: "Tree wire performance has been very satisfactory. Where properly installed with sufficient clearance from heavy limbs, no failures have occurred."

The foregoing statistics and statements, I believe, are ample to indicate that satisfactory performance may be expected and obtained from tree wire in open construction.

*Standards of Construction—*

Few companies replying to the questionnaire had any standards of construction relating to tree wire; what information has been collected is given below:

*Spans*—Spans of 150 ft. and 200 ft. have been found to be most satisfactory, owing to the fact that tree wire weighs so much more per foot than weatherproof and bare wire. Recently one of the manufacturers announced the production of a tree wire consisting of steel and aluminum conductors. This should result in a considerable reduction in weight, and, due to the steel, should permit longer span lengths; no performance of this tree wire has been reported as yet.

*Intra-span Splices*—Some companies do not permit the splicing of the tree wire to the weatherproof or bare conductor in the middle of the span, but insist upon its being carried to the next pole and there deadended. This practice

*Fig. 4. Two 11-kv. circuits utilizing 7-kv. tree wire.*

results in the section of tree wire being deadended at each end. These companies claim that if intra-span splices are permitted, then in due course of time the sag in the spans adjacent will be pulled out, due to the tree wire weighing so much more per foot than the ordinary line wire.

Other companies insist upon the tree wire being installed in full span lengths from pole to pole. It is then tied-in to top groove pin insulators and the line splice made in the span away from the tree wire span; the tree wire is usually continued approximately 25 ft. in both directions, in order to eliminate any trouble from small falling branches or twigs.

Still other companies insert a piece of tree wire right into the line where bad tree conditions exist, sufficient tree wire being installed to extend beyond the tree or trees in each dirction. At the ends of the section of tree wire, splices are made to the regular conductor.

There seems to be a wide difference in opinion relative to intra-span splices. The first two methods have met with considerable success and appear to be reasonable and safe practice; the last method should not be permitted if the section of tree wire to be inserted is of any considerable length and weight, because sag in the adjacent spans will be pulled out.

*Splices*—A good method of splicing tree wire is described by an Eastern utility that has a large amount of tree wire on its system, as follows:

(a) For solid wires, copper sleeves are used; no solder. The insulation applied is two layers of varnished cambric and two layers of friction tape. The insulation is then painted with insulating paint.

(b) For stranded wire, wrap joints are used. After soldering, two layers of varnished cambric and two layers of friction tape are applied and then painted.

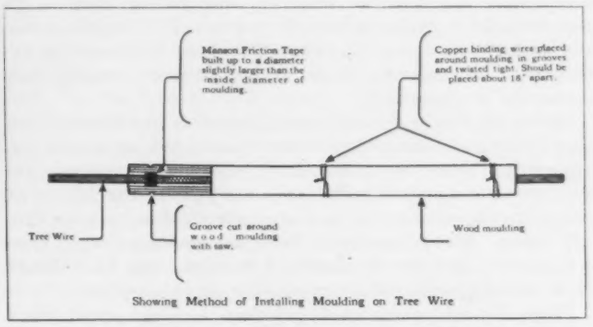
*Deadending*—The methods of deadending tree wire to a crossarm are practically the same as for weatherproof wire. In some instances, the larger users of tree wire have designed and are using special deadend clevises.

*Tree Insulators*—

Tree insulators have been produced that can be attached to trees. The tree wire is suspended on these insulators as support, in order to keep it clear of tree limbs, thus preventing abrasion of the tree wire by the limbs. Thirty-three companies of those replying do not use tree insulators. Six companies do. Three companies use tree insulators in special cases only. Of those regularly using tree insulators, three have found them to be entirely satisfactory; the remaining three have not as yet had sufficient experience to determine if they are satisfactory. One company stated that at one time it had used tree insulators but had to discard them, as the abrasive effect of the insulators was almost as bad as that of the tree limbs.

*Abrasion Guards*— .

An abrasion guard consists of two pieces of wood made into such form that when they are placed over a piece of tree wire, they will completely surround it, preventing undue abrasion from the rubbing of the tree limbs against the wire. Abrasion guards are sometimes called tree molding. Figs. 5 and 6 illustrate the proper method of installation and the


Manson Friction Tape built up to a diameter slightly larger than the inside diameter of moulding.
Copper binding wires placed around moulding in grooves and twisted tight. Should be placed about 18" apart.
Tree Wire
Groove cut around wood moulding with saw.
Wood moulding

Showing Method of Installing Moulding on Tree Wire

*Fig. 5. Method of installing molding on tree wire.*

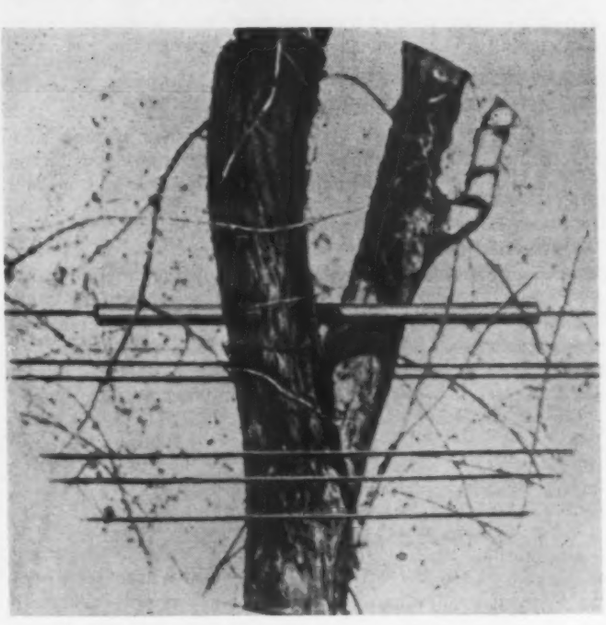


*Fig. 6. A close-up of tree wire with molding.*

use of abrasion guards. Guards improperly made and improperly installed probably will result in as rapid failure of the tree wire as will the abrasion of the tree limbs which they were installed to prevent. Therefore, careful attention should be given to proper installation.

Twenty-five companies reported that they do not use abrasion guards of any sort, sixteen that they use them regularly. Various types of guards were reported, some companies using N.E.L.A. standard wood molding, split fiber duct, etc.

*Trimming of Trees—*

Probably the best thing that can be done to prolong the life of tree wire at the time of its installation is to see that minimum contacts with trees exist. This can be accomplished by doing as much tree trimming as possible when it is installed.

Twenty-six companies advised that this was their practice —in fact, one of the largest users stated that it not only did the desired tree trimming upon installation but also regularly each year thereafter. Fifteen companies replied that they did no trimming whatsoever at the time of installation, because their reason for installing the tree wire was to eliminate any necessity of tree trimming.

*Operating Experiences—*

Reports received indicate that satisfactory performance has been obtained from tree wire in open construction. No particular difficulties have been experienced.

In reply to the question relative to the breakage of tree wire due to the limbs of trees or trees falling upon it, 28 companies answered that they do not have this trouble, while nine companies stated that they do. This difference in experience is no doubt due to the amount of tree trimming that is done by the companies.

The usual causes of failure, as reported, are direct lightning strokes, abrasion of the tree wire by branches of trees, poles being broken by automobiles, poor quality of tree insulators, improperly installed abrasion guards, the falling of trees onto the conductors, and occasionally from a poor factory splice. The foregoing failures are common to any type of conductor that may be used and therefore tree wire should not be unduly penalized when considering this record.

Thirty-six companies answered that they had experienced no static discharge whatsoever from tree wire in this type of construction. One company had experienced such discharge formerly, when a steel armored tree wire was used. Two companies had experienced radio trouble when the insulation of the tree wire wore through.

*Effect on Public Relations—*

Thirty-one companies advised that the use of tree wire had resulted in better public relations; four companies stated that it had not; five companies were undecided, and one did not know.

*Opinions of Operating Companies—*

Each utility was requested to express its opinion relative to the use of tree wire as a satisfactory solution for overcoming tree conditions. Twenty-eight utilities answered that tree wire was a satisfactory solution; five utilities replied that it was not; four utilities replied, "Only as a last resort," and one that it was second to tree trimming.

*Discussion—*

There appears to be a decided difference in the practices of the various utilities relative to the care and use of tree wire.

Some utilities at the time of installation do as much of the required tree trimming as possible in order to eliminate contacts between the wire and the trees. Where such contacts cannot be eliminated abrasion guards or tree insulators are installed. These utilities consider that any wire would chafe off in time. They believe tree wire is an improvement over ordinary weatherproof wire and will result in decided improvement in operation if properly installed and maintained.

Other utilities install the tree wire and do no tree trimming either at or after the installation. These utilities believe that it is the function of the tree wire to resist all hazards that may arise thereafter.

Still other utilities not only trim the trees at the time of installation and install the required abrasion protection, such as guards, etc., but they also trim the trees annually.

Such differences in practice are bound to result in differences in performance. Tree wire is very much like any other material—if it is desired to obtain a reasonable life and performance, it must be properly installed and conscientiously maintained. How much money shall be spent initially and annually is entirely a matter of economics and can be arrived at in the same manner as on other items, such as poles, transformers, etc. It is the writer's belief that each utility using or considering the use of tree wire should look into this subject more carefully, determining for itself what performance it desires of tree wire and choosing accordingly the proper voltage of tree wire, the abrasion protection to be given, and the maintenance to be done periodically.

## Tree Wire—Cable Ring Construction

*Distribution and Performance—*

The use of tree wire in cable ring construction to date has been rather limited. Only four of the 54 companies reporting stated that they had used this type of construction, and of these, two advised that their installations were experimental only.

As there is very little of this type of construction and as practically all of it has been in existence less than five years, the statistics have been combined and are as follows:

| | |
|---|---|
| Total number of companies using cable ring construction | 4 |
| Total amount of multiple conductor installed | 2.06 miles |
| Total amount of single conductor installed | 10.18 miles |
| Total amount of tree wire, all kinds, installed | 12.24 miles |
| Total amount of messenger or cable ring construction | 5.37 miles |
| Total number of failures | 30 |
| Failures per 100 miles of cable ring construction (i.e. messenger) | 559 |
| Failures per 100 miles per year | 186 |

The failures per 100 miles per year is based upon three years of operation. From data furnished by the companies, this appears to be a conservative assumption.

It is interesting to note that 57 per cent of this type of construction is installed outside of the P.C.E.A. territory and that 73 per cent of the total failures have occurred in that territory.

*Voltages and Special Features—*

There appears to be a wide difference in practice as to the voltage rating used for each operating voltage, as indicated below.

TABLE III

| Operating Voltages | Circuit Connection | Rating of Tree Wire |
|---|---|---|
| 2.3 kv. | delta | 5 kv. |
| 3.6 kv. | star | 6 kv. |
| 4.0 kv. | star | 5 kv. |
| 5.0 kv. | delta | 5 kv. |
| 11.5 kv. | star | 9 kv. |

Most of the companies have been and are still using ordinary tree wire for cable ring construction. One company about three years ago, due to its number of failures, especially on its 11-kv. circuits, decided to use a shielded tree wire consisting of a metallic tape wound spirally around the insulation.

*Standards of Construction—*

Each company appears to have its individual methods for this type of construction. The following are some of the

high lights, which may be of value to a utility contemplating the use of cable ring construction.

*Spans*—Spans as long as 200 ft. are satisfactory for this type of construction.

*Fig. 7. 11-kv., 3-phase installation.*

*Messenger and Methods of Deadending Messenger and Tree Wire*—The messengers reported to have been used are high strength steel, Siemens-Martin stranded galvanized guy wire, and copperweld wire. Due to the high initial cost of cable ring construction, it appears advisable to install a messenger of such qualities that the rusting action of the elements will be resisted. The size of the messenger used of course depends upon the weight of tree wire to be supported. One company installs the messenger in accordance with The American Telephone and Telegraph Company's standards for aerial cable messenger; other companies calculate their own sags, etc. One company reports that it deadends the messenger in a strain insulator approximately 2 ft. from the pole; the tree wire leaves the messenger outside of the strain, fans out to the arm, where it is supported by insulators, and is carried across and connected to the line wire after being turned in the down position to prevent water running into the insulation.

*Cable Rings and Saddles*—Some sort of hanger is necessary to suspend the tree wire conductors from the messenger. Some companies use hangers made of marlin twine; others use metal cable rings. When rings are used, if the bottom portion of the ring is not of the proper shape and width, then it is necessary to use a cable saddle in order to reduce the chafing of the tree wire. The marlin hangers or cable rings are usually spaced 15 in. to 18 in. apart.

*Splices*—The two companies which have installations of multiple-conductor tree wire make their splices by using soldered split sleeves, then building up the joints in a manner similar to underground cables, using rubber tape, cloth tape, filler, waterproofing, etc.

With single-conductor tree wire, the type of splice to be used depends upon the kind of tree wire to be spliced. For non-shielded tree wire the conductor is served and soldered, or the splice is made by a split copper sleeve; one company then applies linotape, friction tape and paint ; another company applies rubber tape, friction tape, paint and then covers the entire taped splice with a micarta tube. Shielded conductor splices are usually made in accordance with manufacturer's specifications; these can be obtained from the manufacturers.

Splices in this type of construction should, of course, be avoided if possible, as they are the points of weakness. This

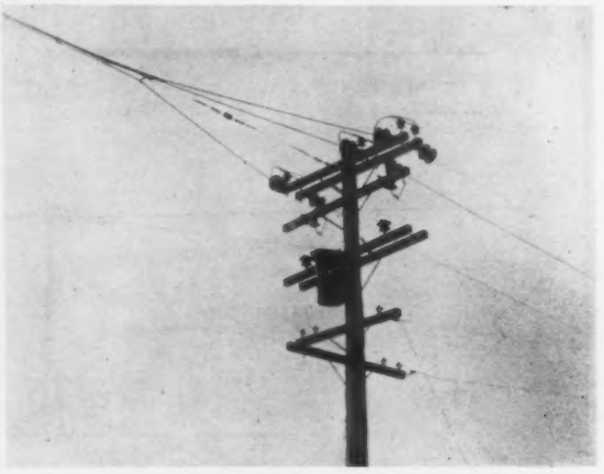


*Fig. 8. 11-kv. 3-phase installation.*

can be accomplished by using care in properly estimating the length of conductors to be used so that the entire run can be made in one length.

*Bonding and Grounding*—All companies are agreed that the messenger should be grounded. One company grounds the messenger every third pole, another company every fourth pole, the two remaining companies did not state how often they grounded their messenger. General Order No. 64A of the California Railroad Commission specifies that the messenger shall be grounded at both ends and at intermediate points not exceeding 800 ft. apart.

Those companies using single-conductor tree wire with a metallic tape, bond the tape to the messenger, no special distance between bonds being specified. One utility advised that originally the metallic tape was bonded and grounded with

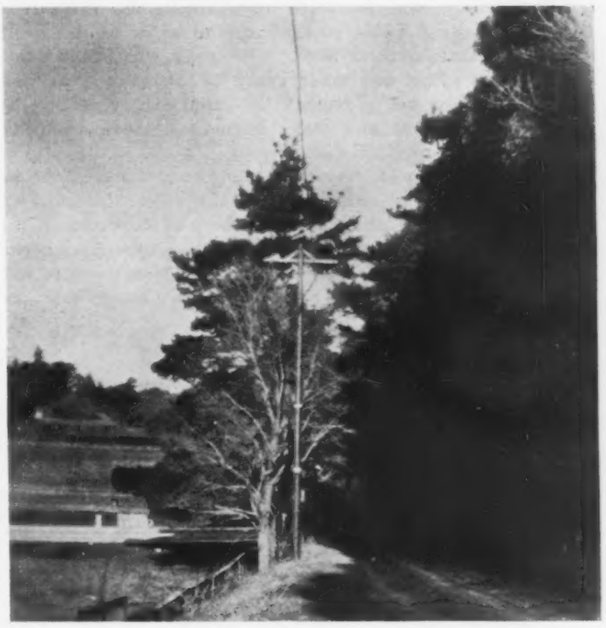


*Fig. 9. 4-kv., 3-phase installation. This is the installation in which Marlin twine was wrapped around the three tree wire conductors and neutral wire.*

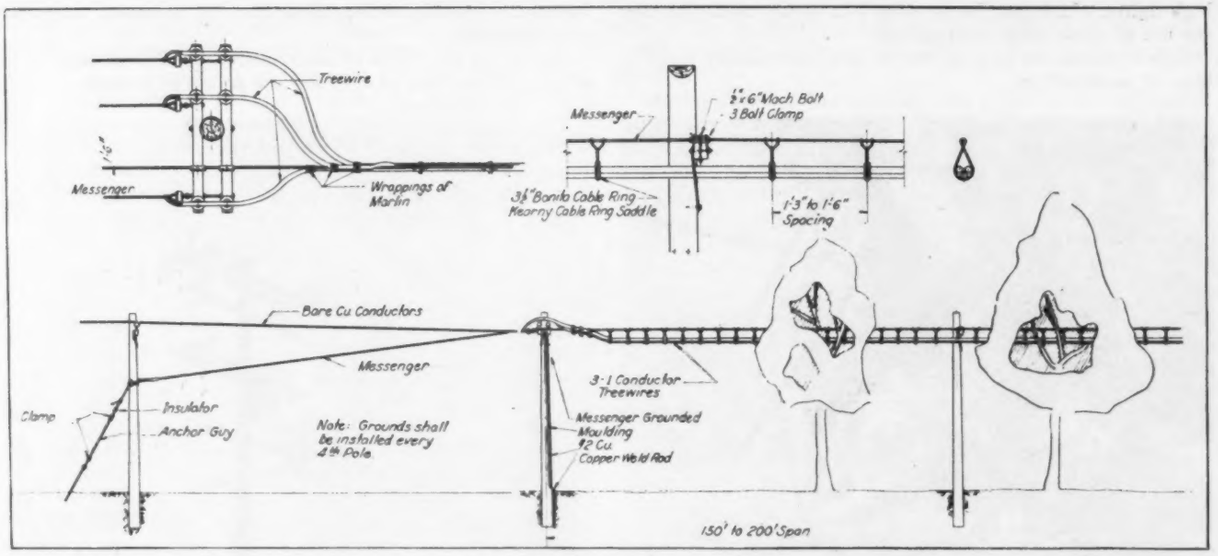



***Fig. 10. Illustrates one method used by a California utility for installing tree wire in cable ring construction.***

the messenger only at the ends of the relatively short sections; the potential which built up between these points, however, caused a discharge and it was necessary to bond the metallic sheath to the messenger on every other pole to eliminate this discharge. Since doing this, satisfactory operation has been obtained.

*Taps*—For single-conductor tree wire, taps for transformers, etc., are brought out as illustrated in Fig. 7. The tap splice is made as previously described under splices.

For multiple-conductor tree wire, taps, as reported by one company, are made by stripping the conductor bare, then making the tap, then taping up the tap and covering it with a weatherproof insulating paint.

*Operating Experiences—*

One company advised that on one installation it had experienced static burns in the insulation of the tree wire without a metallic tape, where cable ring construction was used.

This condition was overcome by wrapping the three tree wires with marlin twine so that all the wires would lie in close contact along their axes. The wrap was about 2 in. apart and a hitch was made every 18 in. One year has elapsed since the above remedy was applied. A recent inspection disclosed no new static burns and the installation to date has operated satisfactorily.

One company has experienced a number of failures due to lightning, which necessitated the installation of lightning protection apparatus at each end of the tree wire run.

Those installations where tree wire has been used with metallic tape and where proper bonds have been made to the messenger and the messenger grounded, have experienced no failures to date.

*Opinions of Operating Companies—*

The replies seemed to indicate that tree wire in cable ring construction is justified only in cases where open construction cannot be used, and also as a last recourse to avoid underground.

As to whether tree wire is better than lead-covered cable with cable ring construction, three companies advised that their experience with tree wire was too limited to enable them to pass judgment; one expressed the opinion that it should be better than lead-covered cable which has a commercially pure lead sheath.

*Discussion—*

It appears to the writer that, in view of the poor operating record experienced to date with this type of construction, very careful consideration should be given to the type of tree wire to be installed, to the comparison of the initial investment with that of aerial lead-covered cable, to the maintenance costs required after the installation, and to the safety to employees.

## *Part II—Aerial Lead-covered Cable*

### Where Used and Its Advantages

1. Where tree conditions are such as to prohibit use of open wires, including tree wire.
2. Where cable of some kind is necessary, but the greater cost of underground construction is prohibitive.
3. Where complicated situations, such as crossing bridges, trestles, etc., exist, prohibiting the use of open wire or tree wire.
4. Where the voltage to be used makes it impracticable to have open wire circuits.
5. Where an existing pole line is incapable of carrying any additional open wire circuits, but can accommodate one or more aerial cables below the open wire construction.
7. Where maximum safety is required.
8. Where cost of conduit is not warranted, considering load and future requirements, and where local ordinances do not permit use of open wire construction.

Typical installations are shown in Figs. 11 to 17, inclusive.

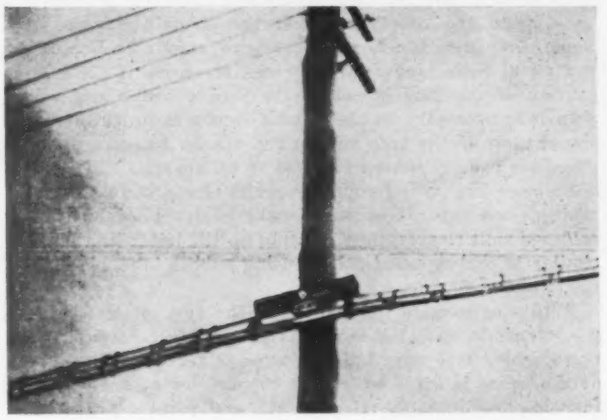


***Fig. 11. Installation showing guard arm, heavy duty suspension clamp and "Ratline" slings, one each side of pole, in place of cable rings to prevent ring cutting.***

### Sizes, Weights, Voltages and Specifications

Lead-covered cable can be obtained in practically any size and voltage desired for this type of constructoin. No table of weights is given, due to this information being available to practically all operating companies. Data regarding special cables can be obtained from the various manufacturers upon request.

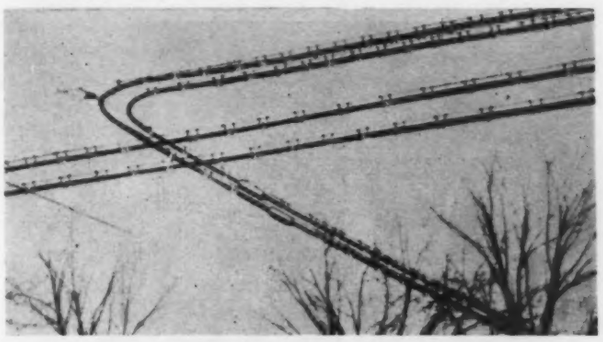


*Fig. 12. Span crossover of two aerial cables.*

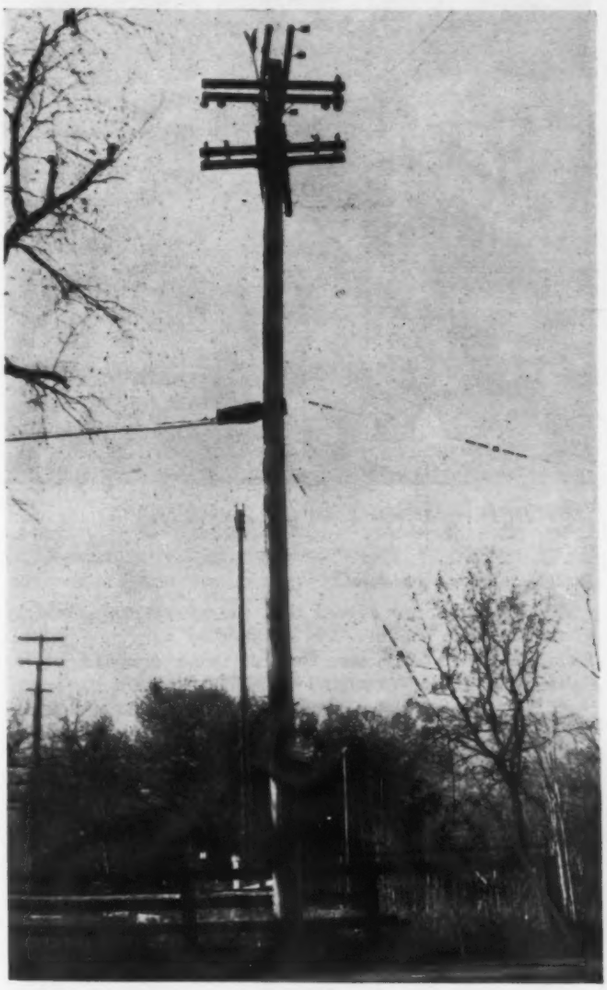


*Fig. 13. Terminal pole of 4-kv., 3-phase aerial lead covered cable installation.*

The following table indicates the operating voltages for which companies have aerial lead-covered cables (multiple-conductor) in service.

TABLE IV

| Number of Companies | Operating Voltage | Voltage Rating of Cable |
|---|---|---|
| 2 | 26 kv. | 26 kv. |
| 2 | 24 kv. | 24 kv., 28 kv. |
| 2 | 13.8 kv. | 15 kv. |
| 3 | 13 kv. | 13 kv., 13.5 kv., 15 kv. |
| 1 | 11 kv. | 15 kv. |
| 1 | 5 kv. | 7.5 kv. |
| 5 | 4 kv. | 4 kv., 4.5 kv., 5 kv. |
| 1 | 3.6 kv. | 6 kv. |
| 1 | 2.3 kv. | 4 kv. |

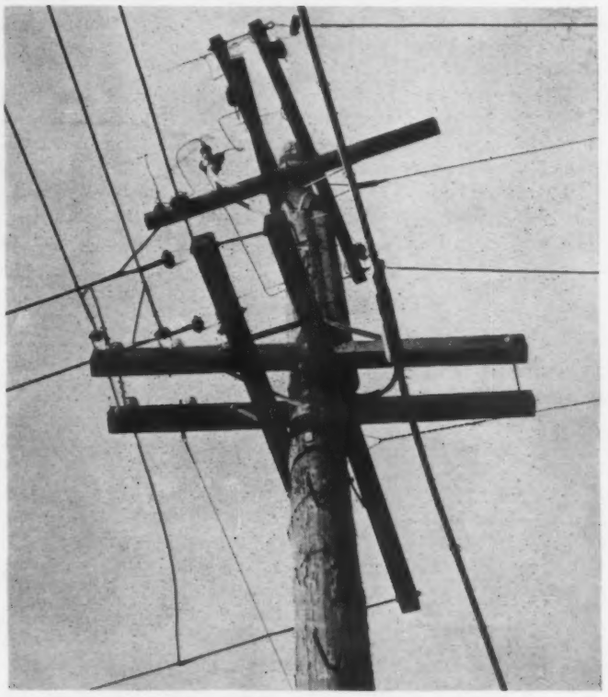


*Fig. 14. Three-phase, 3-conductor tap into 4-kv., 3-phase aerial lead covered cable.*

Ten companies replied that they use the same cable for aerial construction that they use for underground construction; two companies use a special cable.

All aerial cables reported were multiple-conductor. Some companies use commercially pure lead for the sheaths while others use lead sheaths containing antimony, ranging up to 1 per cent.

### Distribution and Performance

The following statistics have been compiled to give an idea of past performances.

Total for All Territories (11 Companies Reporting)

| | Amount In Miles | Failures Per 100 Miles | Failures Per 100 Miles Per Year |
|---|---|---|---|
| Installed 5 years or over | 27.18 | 62.60 | 12.52 |
| Installed less than 5 years | 47.85 | 6.27 | 2.09 |
| Totals | 75.03 | 26.70 | 7.16 |

The above mileage includes only that aerial lead-covered cable for which actual operating figures were given. In addition to this there was one company, with a total of 47.35 miles on its system, which reported that it had fewer aerial cable failures than it experienced on cable installed in its underground system. Including this figure, the total amount of aerial lead-covered cable installed for the twelve reporting companies is 122.38 miles.

It should be noted that the amount of aerial cable installed in P.C.E.A. territory is relatively small compared to that reported as installed throughout the remainder of the country;

being a little over twelve percent. On the other hand, there are 34 times the number of failures per 100 miles per year in P.C.E.A. territory than in the territory east of the Pacific Coast.

The probable reasons for the marked difference in performance between the various sections will be considered later in the report.

## Standards of Construction

*Spans—*

The usual span is about 150 ft. in length. Shorter and longer spans have been used successfully.

*Messenger—*

The messengers reported to have been used are high strength galvanized steel, copperweld, etc. The same recommendations apply here as given under cable ring construction when tree wire is used.

There are various methods of attaching the messenger to the pole. One successful method is to pass the messenger through a three-bolt suspension clamp, which is bolted to

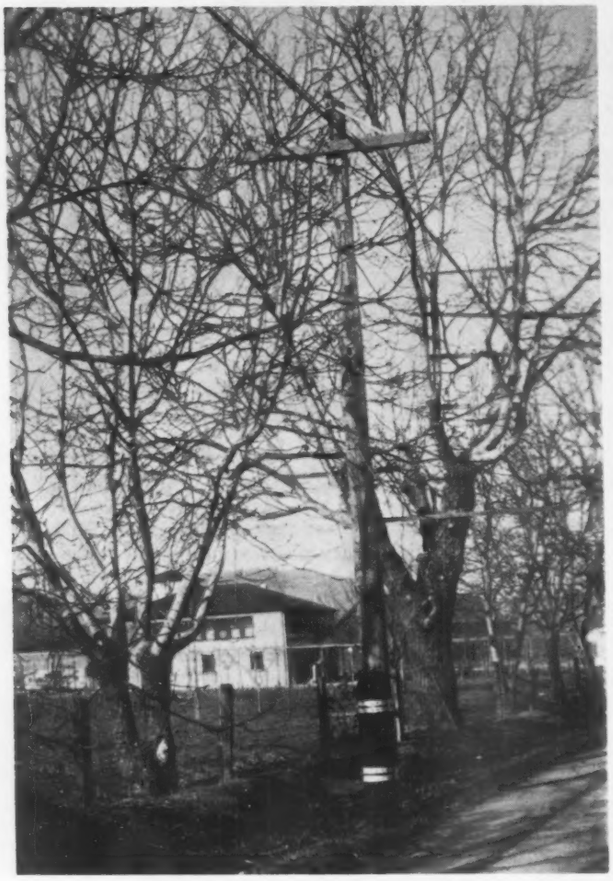


*Fig. 15. 4-kv., 3-phase aerial lead covered cable installation.*

the pole, a reinforcing strap being attached to the suspension clamp to take some of the strain of the messenger from the suspension clamp.

Messenger splices can be made with clips or clamps.

Each company appears to have its own method for deadending the messenger. One recommended method is to run the messenger one pole beyond the cable terminal, take two turns around the pole and clamp; then guy to the next pole or to anchor guys.

*Cable Rings and Saddles—*

See the consideration of this subject under tree wire, cable ring construction. At the poles, marlin twine is used for suspending the cable from the messenger and at places where it is difficult to use the wire ring, such as at messenger splices, etc.

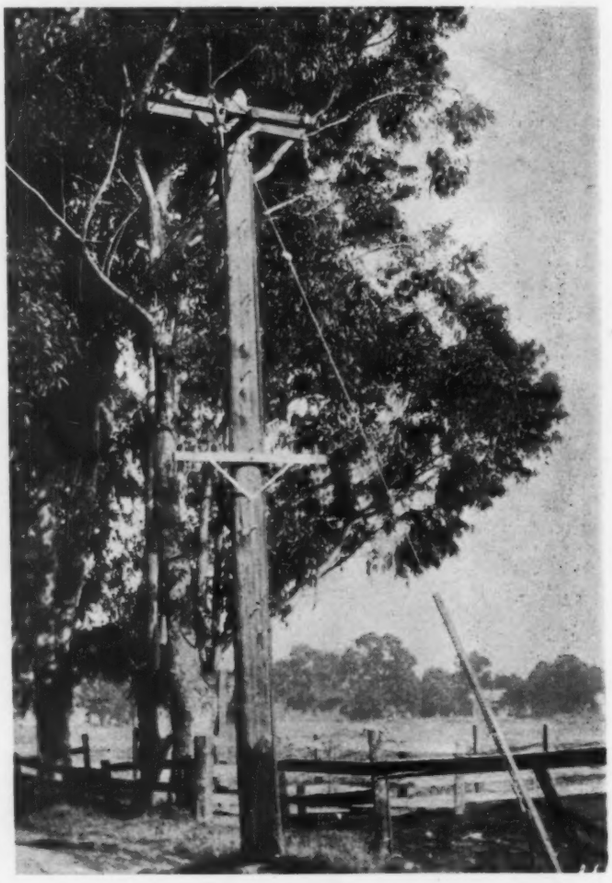


*Fig. 16. 11-kv., 3-phase aerial lead covered cable installation.*

*Bonding and Grounding—*

All companies are agreed that the messenger should be grounded. The grounds are installed at varying intervals from 800 ft. to 10 spans; General Order No. 64A of the California Railroad Commission specifies that the messenger shall be grounded at both ends of the messenger and at intermediate points not exceeding 800 ft. apart.

The various companies bond the cable sheath to the messenger at different intervals. One company bonds on each side of the cable splice; another bonds at 400-ft. intervals. In California, General Order No. 64A specifies that, when a cable is inclosed in a metal sheath, each section of the cable between splices shall be permanently bonded to the messenger at not less than two locations.

*Cable Splices and Taps—*

Splices or joints in aerial cable are made in the same manner as in underground cable. One company suspends the cable joints from the messenger by means of a copper strip wrapped around the messenger and joint, and soldered to both the messenger and the joint sleeve; this acts not only as a support to the joint, but also as a bond between the cable and the messenger.

Reports indicate that there are very few cases where cable is used to supply transformers; most cables are used for transmission purposes only. When transformers are supplied, three single-conductor cables are brought out and

terminated in single-conductor outdoor potheads; a three-conductor splice on the main cable is used.

### Use of Antimony

Of the 54 companies replying to the questionnaire, only 12 stated that they had aerial cable installations on their systems. Of these twelve companies, six used commercially pure lead sheaths, while five used lead sheaths containing antimony, ranging from one-half to one per cent, and one company used lead sheath containing 3 per cent tin.

Those companies using antimony in the sheath experienced no trouble from their sheaths, while those using the commercially pure lead sheaths have experienced crystallization and breakage.

Of the 75.03 miles of cable for which operating data was reported, 60.26 miles contained antimony, 0.24 miles contained tin, and 14.53 miles had commercially pure lead sheaths. The total number of failures recorded to date are three, none, and seventeen respectively. This indicates that the cable with antimony in the sheath has a considerably better performance record than the cable with commercially pure lead sheaths.

It may be of interest, at this time, to give an idea of what qualities antimony possesses which make a small amount of it so desirable in the sheaths of aerial lead-covered cables. According to charts in an article entitled "Fatigue Studies of Telephone Cable Sheath Alloys," by John R. Townsend of the Bell Telephone Laboratories, Inc., published in February, 1928, the number of vibrations to failure of a lead sheath of a telephone cable under test increased from less than 1,000,000 vibrations for the sheath of commercially pure lead to almost 12,000,000 vibrations for the sheath with 1 per cent antimony. Likewise for a cable sheath under bending tests, the number of bends to failure increased from less than 250,000 bends for the commercially pure lead sheath to over 3,000,000 bends for the sheath containing 1 per cent antimony. It appears that antimony has the property of hardening the lead sheath. It is of interest to know that practically all telephone cables, both aerial and underground, have sheaths consisting of 99 per cent lead and 1 per cent antimony.

From the above tests and printed data, as well as from the performance records of those companies that have used antimony in their cable sheaths, it appears that the electric utilities can very well give consideration to the use of antimony in the lead sheaths when planning aerial cable installations.

### Operating Experiences

One company, upon a recent inspection of an aerial cable installation, found 32 breaks in the sheath of the cable, a break occurring at each pole. This breakage in the sheath was partly due to lack of maintenance and partly to the fact that the sheath consisted of commercially pure lead only. No failures of this cable had occurred, however.

One company experienced damage to the lead sheath of the cable due to the bombardment by cinders from passing locomotives.

Some companies have experienced trouble when the sag of the messenger and cable is not correct.

One company experienced a cable failure due to a woodpecker.

All companies advised that they had experienced no trouble due to cable bugs. One company stated that several years ago it had removed some aerial cable and found some small pin-like holes in the sheath which appeared to be holes made by a bug. No failures of this cable had occurred. The bug idea was discounted; however, an article entitled "Beetles Damage Lead Covered Cables" on page 17, of the Jan. 1, 1931, issue of *Electrical West* indicates that such lead-boring insects do exist and have been found in China, Australia, and Brazil, as well as in California.

All companies reported that they had experienced no trouble due to stray currents.

### Opinions and Comments of Operating Companies

The companies replying indicated that aerial lead-covered cable construction was preferable to other types under all conditions, considering safety, efficiency and economy. It is expenditure of money.

*Fig. 17. 11-kv., 3-phase lead covered cable installed under trestle. Cable sheath contains 3 per cent tin.*

One company stated that great care should be exercised in sag-temperature calculations on account of winter and summer temperature variations.

One company advised that it is making an investigation of the relative absorption of the radiant heat from the sun and of the blocking effect to heat radiation from the conductor of three colored surfaces for aerial cable—white, aluminum and black. This data is being prepared for the underground systems committee of the N.E.L.A.

### Discussion

It was previously noted that the performance of the companies in the territory east of the Pacific Coast was very much better than those in the P.C.E.A. territory. This is without question due to the use of antimony in the lead sheaths by most of the companies located east of the Pacific Coast, while in P.C.E.A. territory no antimony is used in the sheaths. The Eastern companies give much more consideration to the installation of the messenger and cable, to see that proper sags, etc., exist.

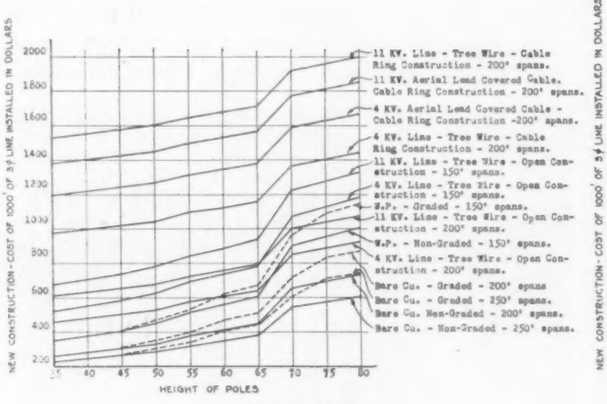
It is the writer's belief that satisfactory performance can be obtained from aerial lead-covered cable providing the cable used contains 1 per cent antimony, and that it is installed properly.

## *Part III—Trenchlay Cable*

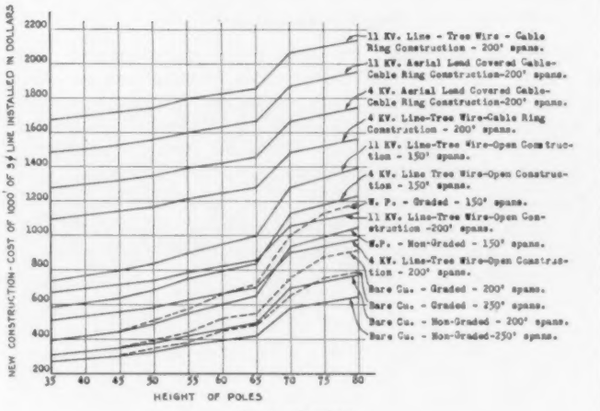
A trenchlay cable, for the purpose of this report, is a cable installed directly in the ground.

This type of construction was not included in the questionnaire, which was sent out to the companies previously mentioned; however, the writer believes it to be of sufficient interest to call to the attention of member companies of the P.C.E.A.

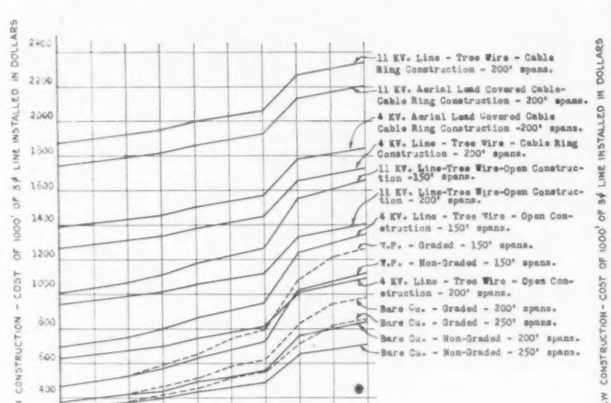
No doubt in some instances where bad tree conditions do exist and where there is a considerable distance between transformers and taps, this type of construction may be used to advantage. Of course the cost will have to be considered. There has been very little experience with this type of construction on the Pacific Coast, hence no operating data can be given at this time.


NEW CONSTRUCTION - COST OF 1000' OF 3φ LINE INSTALLED IN DOLLARS
HEIGHT OF POLES
11 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
11 KV. Aerial Lead Covered Cable. Cable Ring Construction - 200' spans.
4 KV. Aerial Lead Covered Cable - Cable Ring Construction -200' spans.
4 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
11 KV. Line - Tree Wire - Open Construction - 150' spans.
4 KV. Line - Tree Wire - Open Construction - 150' spans.
W.P. - Graded - 150' spans.
11 KV. Line - Tree Wire - Open Construction - 200' spans.
W.P. - Non-Graded - 150' spans.
4 KV. Line - Tree Wire - Open Construction - 200' spans.
Bare Cu. - Graded - 200' spans
Bare Cu. - Graded - 250' spans.
Bare Cu. Non-Graded - 200' spans.
Bare Cu. - Non-Graded - 250' spans.

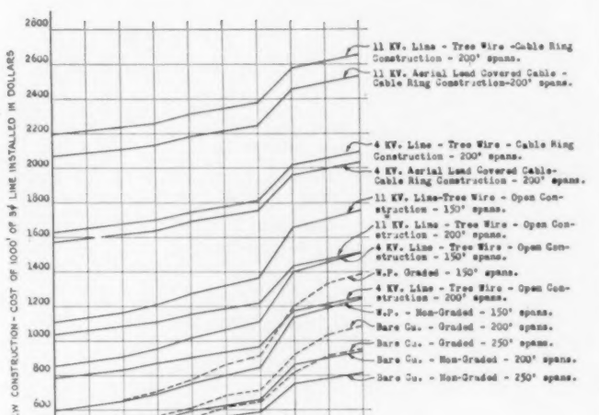
#6 CU. CONDUCTOR
FIG. 1


NEW CONSTRUCTION - COST OF 1000' OF 3φ LINE INSTALLED IN DOLLARS
HEIGHT OF POLES
11 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
11 KV. Aerial Lead Covered Cable- Cable Ring Construction-200' spans.
4 KV. Aerial Lead Covered Cable- Cable Ring Construction-200' spans.
4 KV. Line-Tree Wire-Cable Ring Construction - 200' spans.
11 KV. Line-Tree Wire-Open Construction - 150' spans.
4 KV. Line Tree Wire-Open Construction - 150' spans.
W. P. - Graded - 150' spans.
11 KV. Line-Tree Wire-Open Construction -200' spans.
W.P. - Non-Graded - 150' spans.
4 KV. Line-Tree Wire-Open Construction - 200' spans.
Bare Cu. - Graded - 200' spans.
Bare Cu. - Graded - 250' spans.
Bare Cu. - Non-Graded - 200' spans.
Bare Cu. - Non-Graded-250' spans.

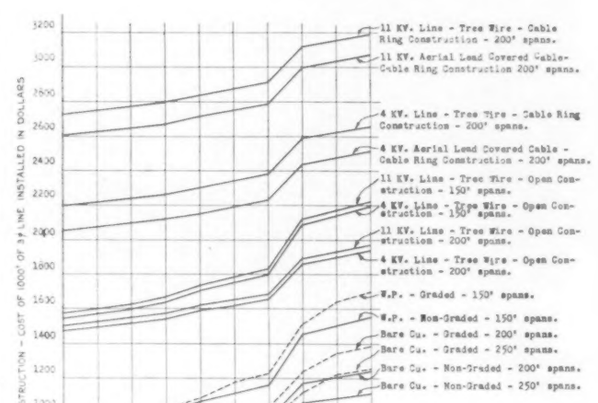
#4 CU. CONDUCTOR
FIG. 2


NEW CONSTRUCTION - COST OF 1000' OF 3φ LINE INSTALLED IN DOLLARS
HEIGHT OF POLES
11 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
11 KV. Aerial Lead Covered Cable- Cable Ring Construction - 200' spans.
4 KV. Aerial Lead Covered Cable Cable Ring Construction -200' spans.
4 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
11 KV. Line-Tree Wire-Open Construction -150' spans.
11 KV. Line-Tree Wire-Open Construction - 200' spans.
4 KV. Line - Tree Wire - Open Construction - 150' spans.
W.P. - Graded - 150' spans.
W.P. - Non-Graded - 150' spans.
4 KV. Line - Tree Wire - Open Construction - 200' spans.
Bare Cu. - Graded - 200' spans.
Bare Cu. - Graded - 250' spans.
Bare Cu. - Non-Graded - 200' spans.
Bare Cu. - Non-Graded - 250' spans.

#2 CU. CONDUCTOR
FIG. 3


NEW CONSTRUCTION - COST OF 1000' OF 3φ LINE INSTALLED IN DOLLARS
HEIGHT OF POLES
11 KV. Line - Tree Wire -Cable Ring Construction - 200' spans.
11 KV. Aerial Lead Covered Cable - Cable Ring Construction-200' spans.
4 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
4 KV. Aerial Lead Covered Cable- Cable Ring Construction - 200' spans.
11 KV. Line-Tree Wire - Open Construction - 150' spans.
11 KV. Line - Tree Wire - Open Construction - 200' spans.
4 KV. Line - Tree Wire - Open Construction - 150' spans.
W.P. Graded - 150' spans.
4 KV. Line - Tree Wire - Open Construction - 200' spans.
W.P. - Non-Graded - 150' spans.
Bare Cu. - Graded - 200' spans.
Bare Cu. - Graded - 250' spans.
Bare Cu. - Non-Graded - 200' spans.
Bare Cu. - Non-Graded - 250' spans.

#1/0 CU. CONDUCTOR
FIG. 4


NEW CONSTRUCTION - COST OF 1000' OF 3φ LINE INSTALLED IN DOLLARS
HEIGHT OF POLES
11 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
11 KV. Aerial Lead Covered Cable- Cable Ring Construction - 200' spans.
4 KV. Line - Tree Wire - Cable Ring Construction - 200' spans.
4 KV. Aerial Lead Covered Cable - Cable Ring Construction - 200' spans.
11 KV. Line - Tree Wire - Open Construction - 150' spans.
4 KV. Line - Tree Wire - Open Construction - 150' spans.
11 KV. Line - Tree Wire - Open Construction - 200' spans.
4 KV. Line - Tree Wire - Open Construction - 200' spans.
W.P. - Graded - 150' spans.
W.P. - Non-Graded - 150' spans.
Bare Cu. - Graded - 200' spans.
Bare Cu. - Graded - 250' spans.
Bare Cu. - Non-Graded - 200' spans.
Bare Cu. - Non-Graded - 250' spans.

#4/0 CU. CONDUCTOR
FIG. 5

COMPARATIVE COSTS OF VARIOUS TYPES OF LINE CONSTRUCTION

Figures 1 to 5 inclusive.

These charts show the cost of 1000 ft. of new 3 phase line installed for the various types of construction. They are based on the following assumptions:-

1. That a 65 ft. pole is the maximum height of pole that can be raised with the ordinary pole raising equipment; poles over 65 ft. in height requiring the use of a gin pole.

2. That the cost of insulators for a 4 KV and 11 KV line is the same.

3. In going over trees, when poles of 50 ft. or higher are required, that it is necessary to grade from a normal load of 35 ft. poles on each side of the 1,000 ft. section under consideration; grading to be done in 10 ft. steps, that is, from 35 ft. to 45 ft. to 55 ft. to 65 ft. The amount charged against "graded" line is the difference in the installed cost of a 35 ft. pole and the installed cost of the higher pole required for grading.

4. That the tree wire used on 4 KV "open construction" is 3,000 volt rating and single conductor.

5. That the tree wire used on 11 KV "open construction" is 7,000 volt rating and single conductor.

6. That the tree wire used on 4 KV "cable ring construction" is 3,000 volt rating, single conductor, and contains a bronze tape as a shield.

7. That the tree wire used on 11 KV "cable ring construction" is 7,000 volt rating, single conductor, and contains a bronze tape as a shield.

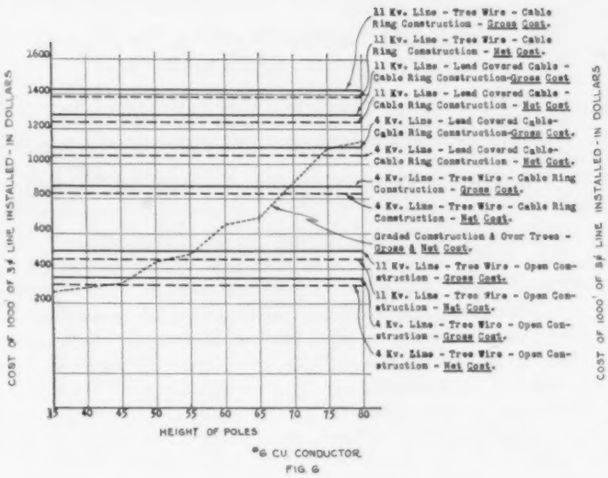
8. That normal construction conditions pertain to the 1,000 ft. section of line under consideration.

EXAMPLE OF USE OF CHARTS

Will it be more economical to build a #6 - 4 KV 3 phase line over the tops of a group of trees or install #6 tree wire, open construction, using 40 ft. poles and 200 ft. spans?

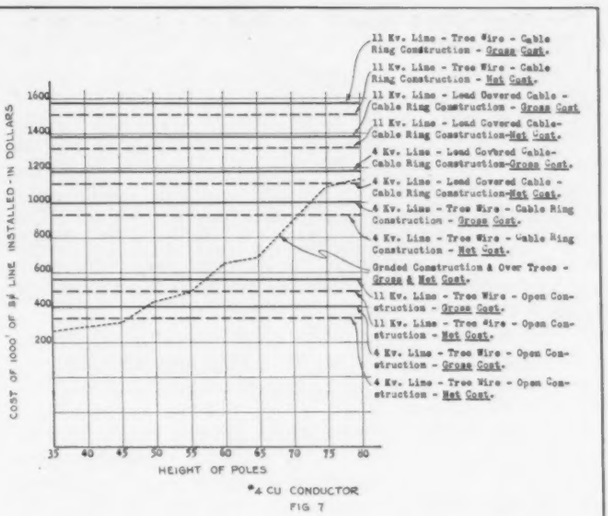
Referring to Figure 1, it will be found that the cost of #6 tree wire, 4 KV open construction, using 40 ft. poles and 200 ft. spans, is $477.00. With this cost of $477.00 as an ordinate and referring to the Bare Copper - Graded construction - 200 ft. span curve, it will be found that 60 ft. poles can be installed for a trifle less cost than the tree wire. If 60 ft. poles will clear the trees sufficiently, then it will be more economical to go over the tops of the trees, however, if 60 ft. poles will not clear the trees sufficiently, then it will be more economical to install the tree wire with open construction.

*Fig. 18. Charts showing comparative costs of line construction.*


11 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
11 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
11 Kv. Line - Lead Covered Cable - Cable Ring Construction-Gross Cost
11 Kv. Line - Lead Covered Cable - Cable Ring Construction - Net Cost
4 Kv. Line - Lead Covered Cable-Cable Ring Construction-Gross Cost.
4 Kv. Line - Lead Covered Cable-Cable Ring Construction - Net Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
Graded Construction & Over Trees - Gross & Net Cost.
11 Kv. Line - Tree Wire - Open Construction - Gross Cost.
11 Kv. Line - Tree Wire - Open Construction - Net Cost.
4 Kv. Line - Tree Wire - Open Construction - Gross Cost.
4 Kv. Line - Tree Wire - Open Construction - Net Cost.
COST OF 1000' OF 3Ø LINE INSTALLED - IN DOLLARS
HEIGHT OF POLES

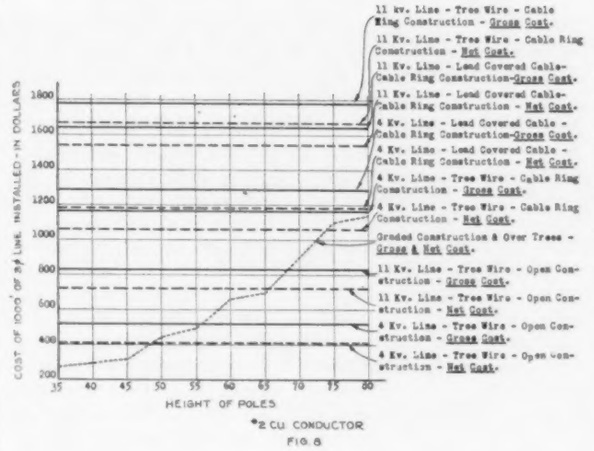
*6 CU. CONDUCTOR

FIG. 6


11 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
11 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
11 Kv. Line - Lead Covered Cable - Cable Ring Construction - Gross Cost
11 Kv. Line - Lead Covered Cable-Cable Ring Construction-Net Cost.
4 Kv. Line - Lead Covered Cable-Cable Ring Construction-Gross Cost.
4 Kv. Line - Lead Covered Cable - Cable Ring Construction-Net Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
Graded Construction & Over Trees - Gross & Net Cost.
11 Kv. Line - Tree Wire - Open Construction - Gross Cost.
11 Kv. Line - Tree Wire - Open Construction - Net Cost.
4 Kv. Line - Tree Wire - Open Construction - Gross Cost.
4 Kv. Line - Tree Wire - Open Construction - Net Cost.
COST OF 1000' OF 3Ø LINE INSTALLED - IN DOLLARS
HEIGHT OF POLES

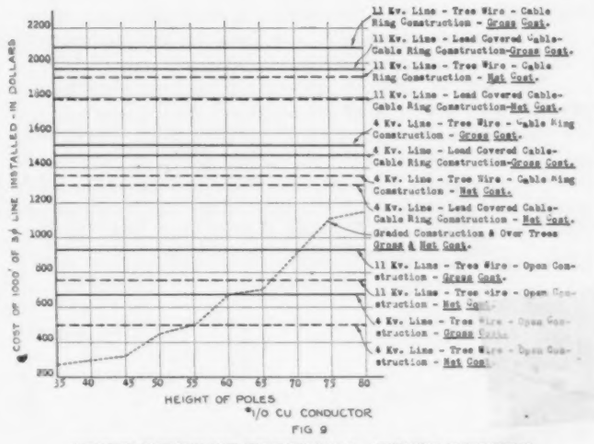
*4 CU. CONDUCTOR

FIG. 7


11 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
11 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
11 Kv. Line - Lead Covered Cable-Cable Ring Construction-Gross Cost.
11 Kv. Line - Lead Covered Cable-Cable Ring Construction - Net Cost.
4 Kv. Line - Lead Covered Cable - Cable Ring Construction-Gross Cost.
4 Kv. Line - Lead Covered Cable-Cable Ring Construction - Net Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
Graded Construction & Over Trees - Gross & Net Cost.
11 Kv. Line - Tree Wire - Open Construction - Gross Cost.
11 Kv. Line - Tree Wire - Open Construction - Net Cost.
4 Kv. Line - Tree Wire - Open Construction - Gross Cost.
4 Kv. Line - Tree Wire - Open Construction - Net Cost.
COST OF 1000' OF 3Ø LINE INSTALLED - IN DOLLARS
HEIGHT OF POLES

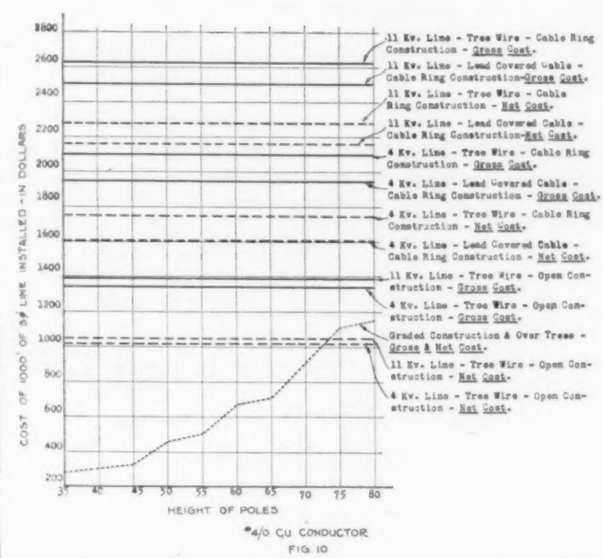
*2 CU. CONDUCTOR

FIG. 8


11 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
11 Kv. Line - Lead Covered Cable-Cable Ring Construction-Gross Cost.
11 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
11 Kv. Line - Lead Covered Cable-Cable Ring Construction-Net Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
4 Kv. Line - Lead Covered Cable-Cable Ring Construction-Gross Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
4 Kv. Line - Lead Covered Cable-Cable Ring Construction - Net Cost.
Graded Construction & Over Trees - Gross & Net Cost.
11 Kv. Line - Tree Wire - Open Construction - Gross Cost.
11 Kv. Line - Tree Wire - Open Construction - Net Cost.
4 Kv. Line - Tree Wire - Open Construction - Gross Cost.
4 Kv. Line - Tree Wire - Open Construction - Net Cost.
COST OF 1000' OF 3Ø LINE INSTALLED - IN DOLLARS
HEIGHT OF POLES

*1/0 CU. CONDUCTOR

FIG. 9


11 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
11 Kv. Line - Lead Covered Cable - Cable Ring Construction-Gross Cost.
11 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
11 Kv. Line - Lead Covered Cable - Cable Ring Construction-Net Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Gross Cost.
4 Kv. Line - Lead Covered Cable - Cable Ring Construction-Gross Cost.
4 Kv. Line - Tree Wire - Cable Ring Construction - Net Cost.
4 Kv. Line - Lead Covered Cable - Cable Ring Construction - Net Cost.
Graded Construction & Over Trees - Gross & Net Cost.
11 Kv. Line - Tree Wire - Open Construction - Gross Cost.
11 Kv. Line - Tree Wire - Open Construction - Net Cost.
4 Kv. Line - Tree Wire - Open Construction - Gross Cost.
4 Kv. Line - Tree Wire - Open Construction - Net Cost.
COST OF 1000' OF 3Ø LINE INSTALLED - IN DOLLARS
HEIGHT OF POLES

*4/0 CU. CONDUCTOR

FIG. 10

REPLACEMENT OF EXISTING POLES WITH HIGHER POLES Vs. INSTALLATION OF TREE WIRE OR AERIAL LEAD COVERED CABLE ON EXISTING POLES

Figures 6 to 10 inclusive

These charts show the relative costs of replacing existing poles with higher poles in order to clear trees, the installation of tree wire both with open construction and with cable ring construction, and of aerial lead covered cables with cable ring construction on existing poles. They cover 1,000 ft. sections of 3 phase line and are based on the following assumptions.

1. That a 65 ft. pole is the maximum height of pole that can be raised with the ordinary pole raising equipment; poles over 65 ft. in height requiring the use of a gin pole.

2. That the cost of insulators for a 4 KV and 11 KV line is the same.

3. In going over trees, when poles of 50 ft. or higher are required, that it is necessary to grade from a normal lead of 35 ft. poles on each side of the 1,000 ft. section under consideration; grading to be done in 10 ft. steps, that is, 35 ft. to 45 ft. to 55 ft. to 65 ft. The amount charged against "graded" line is the total installed cost of the higher pole required for grading.

4. That 200 ft. is the normal span length.

5. That those poles, which are removed when higher poles are set in order to go over the trees, are of no salvage value.

6. For tree wire with open or cable ring construction and for aerial lead covered cable with cable ring construction, that the existing poles are properly spaced and are of satisfactory condition to take on such construction.

7. That the tree wire used on 4 KV and 11 KV "open construction" is 3,000 volt and 7,000 volt rating respectively and are single conductor.

8. That the tree wire used on 4 KV and 11 KV "cable ring construction" is 3,000 volt and 7,000 volt rating respectively and are single conductor and contain a bronze tape as a shield.

9. That normal construction conditions pertain to the 1,000 ft. section of line under consideration.

EXAMPLE OF USE OF CHARTS

Trees have grown up into an existing #6 Bare Copper 4 KV line and have resulted in interruptions to service. Will it be more economical to replace the existing poles with higher poles and go over the tops of the trees or to leave the present poles in place and replace the bare conductors with tree wire, open construction?

Referring to Fig. #6, it will be found that the gross cost of replacing the #6 bare conductors with #6 tree wire, 4 KV open construction, is $347.00. This ordinate ($347.00) intersects the "Graded Construction & Over Trees" curve between 45 ft. and 50 ft. poles. This indicates that 45 ft. is the maximum height of pole that can be economically used. Therefore, if 45 ft. poles will clear the trees sufficiently, then it will be more economical to go over the tops of the trees with higher poles, however, if 45 ft. poles will not clear the trees sufficiently, then it will be more economical to install the tree wire with open construction.

*Fig. 19. Charts comparing replacement of existing poles vs. insta llation of tree wire on aerial lead covered cable on existing poles.*

Trenchlay cable is usually installed at a depth of 12 in. to 18 in., depending upon soil conditions. Sometimes it is advisable to install it at a depth greater than this. Various types of plows have been developed for the installation of this type of cable. These plows open the earth and lay the cable automatically. Sometimes it is advisable to protect the cable by laying a plank over it. In crossing under streets the cable is usually installed in a pipe, as a protection from the strains of heavy loads passing over it. Pipe is also installed where the cable is carried from the trench up the pole for connection to the overhead lines. The cable may be terminated in potheads or porcelain expulsion type cutout boxes.

### *Part IV—Economics of Eliminating Tree Interference*

It appears to the writer that the question of the method or combination of methods to be used for eliminating tree interference is largely a matter of economics. In arriving at the proper method to use, some monetary value must be placed on continuity of service, safety to employees and the public, the effect on public relations, etc., as all of these have a direct bearing on the methods to be employed in relieving the interference.

In order that an idea of the relative costs of the various types of construction may be obtained, three charts have been prepared and are included in this report. They are Fig. 18, "Comparative Costs of Various Types of Line Construction," Fig. 19, "Replacement of Existing Poles with Higher Poles Versus Installation of Tree Wire or Aerial Lead Covered Cable on Existing Poles," and Fig. 20, "Installed Costs of Trenchlay Cable."

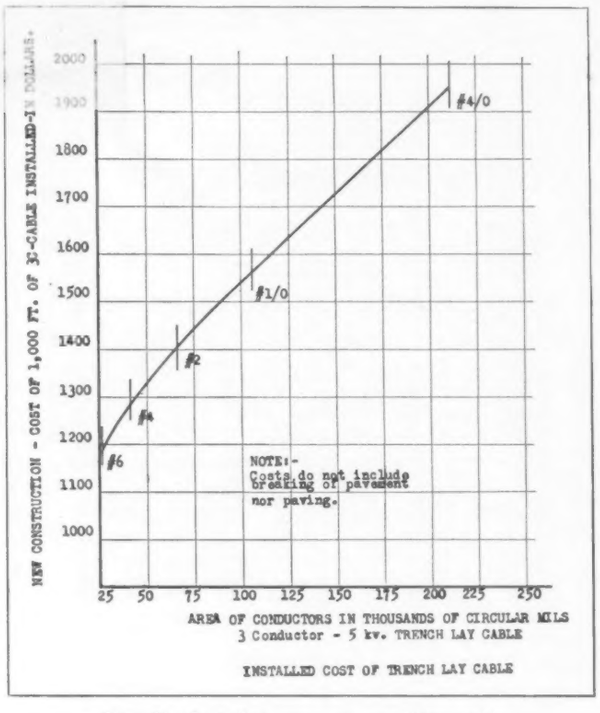



*Fig. 20. Installed cost of trenchlay cable.*

These charts are self-explanatory and each contains a statement as to the assumptions that were made in its compilation. Figs. 18 and 19 contain practical examples illustrating their use.

It should be especially noted, when open construction with either bare or weatherproof wires is used in going over the tops of trees, that the costs of the required grading is included in the cost of construction, and that all poles are butt treated.

Some interesting high lights of Fig. 18, "Comparative Costs Versus Types of Line Construction," are:

1. That 11-kv. tree wire in cable ring construction is more costly than 11-kv. lead-covered cable in cable ring construction.
2. That 4-kv. tree wire in cable ring construction is less costly than 4-kv. lead-covered cable in cable ring construction for all sizes up to No. 2 copper inclusive; for sizes No. 1/0 and over, the lead-covered cable is cheaper.

Referring to Fig. 19, it will be noted that the net cost is given for each type of construction as well as the gross cost. This is done in order to provide all aspects of the problem.

It is of interest to note that the cost of trenchlay cable installed, as shown on Fig. 20, is the same, for each size, as the cost of aerial lead-covered cable installed on 35-ft. poles.

It will be well for each member company of the P.C.E.A. to prepare similar charts for its own use, as in this way the economics of the problem may readily be analyzed. Construction costs vary with each company, due to location, etc.

### *Part V—Heights and Growth of Trees*

When building a pole line with the aim of setting poles of sufficient height to clear permanently the trees over which the wires are to pass, it is necessary to know the ultimate heights of the trees. Otherwise poles too short may be set and tree interference encountered at a later date. Not only is this information necessary for the actual setting of the poles, but also to determine if it is more economical to set the poles or use shorter poles with other types of construction. With the foregoing thoughts in mind, an endeavor was made to find a suitable table showing the average ultimate heights and the yearly growth of trees on the highways and county roads in California. The only table available is the one published by the California State Board of Forestry and known as Bulletin No. 4, "Street and Highway Planting." This bulletin was published in 1912. The data contained in it, however, do not seem to be of sufficient accuracy and therefore should be used with discretion. Considerable research can be done on this subject and it is recommended that proper contacts be made with the various universities in California to carry on such research.

Several instruments have been developed for determining in the field the actual height of trees. Some of these instruments can be used also for determining the height in feet of any object, such as poles, wires and buildings. The proper use of such instruments should result in great saving to the utility using them, as poles of proper height will then be set.

### *Part VI—Recommendations*

1. That certain definite voltages be chosen as standard rated voltages for tree wires and that a definite test voltage and method of test be established for each rated voltage.
2. That a study be made to determine the proper rated voltage of tree wire for each operating voltage.
3. That a study be made of proper maintenance to be given to the various types of construction described in the report.
4. That a study be made, either jointly or separately, by the utilities and the universities of the State of California to determine the average ultimate heights and yearly growth of trees along the highways and county roads.

### *Part VII—Conclusion*

It is not the intention of this report to favor any particular type of construction or manufacturer's product. The report is intended to call to the attention of the member companies of the P.C.E.A. the various types of construction for which tree wire and lead-covered cable may be used, the performance of each type and some of the problems encountered.

It is believed that each type of construction outlined in this report has its proper place in the distribution field. It is up to each utility to weigh the various factors involved and to make its own decision.

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## *Loading of Transformers**

*The subject of loading of distribution transformers is treated herewith only in those economic and engineering phases involved in determining the proper size transformer to be applied after the size and type of load has been definitely established. Due to wide variations in detailed costs used by different utilities and standards of service maintained no tables of general use have been submitted. Each utility must properly prepare its own tables and regulations to suit its own conditions. Manufacturers and designers should be prepared to meet reasonable trends indicating more favorable proportions of losses or demands for improved regulation.*

THE general subject of the loading of transformers is one involving both engineering and economic questions that cannot be answered by any but the most careful and comprehensive studies not only of the immediate phases of the application of loads to transformers, but also of future trends.

* Report of the subcommittee on distribution transformer operation and maintenance, overhead systems committee, Engineering Section, John B. Madden, chairman, C. A. Andrews, F. E. Blausey, H. L. Caldwell, P. Diederich, C. V. Fairchild, J. W. Finchley, R. B. Gullbault, R. V. Hall, C. L. Lawrie, H. Michener, A. C. Putnam, F. H. Searight, W. C. Smith, A. E. Strong, C. P. Taylor, H. B. Wells.

Various radical or novel changes seem imminent to some authorities—for example, the extensive use of incandescent gas-filled lighting units similar to "neon" tubes is predicted as almost upon us. This will mean the decline of incandescent filament lighting and the disappearance of purely non-inductive loads. New limits of good regulation and efficiency will have to be determined. Changes in character of loads due to changes in "mass-habits" such as attendance at night athletic amusements, five-day week schedules for factories, and like modifications, most certainly will have a definite influence on duration factors, diversity factors, and all the important variables of load cycles.

### Character of the Load

The first problem that is to be met in determining the size of the transformer for a given load is to integrate the load from its several component parts. This in itself is more of an art than an exact science but approaches the latter as a direct function of the load density per unit length of distribution system.

That is to say, as the load density measured in kilowatts per mile of primary circuit increases, the degree of exactness to which the sizes of the individual transformers may be determined is likewise increased, until the point is reached when the load along a particular feeder may be wholly integrated into a secondary network supplied by transformer banks whose size and spacing can be determined with reasonable accuracy.

While closely associated with the general subject of loading transformers, the problem of load integration is one that justifies the complete attention of a group assigned to this problem alone. The available time will not permit this group to do anything but touch the high-spots of the relation of the transformer capacity to loads already integrated.

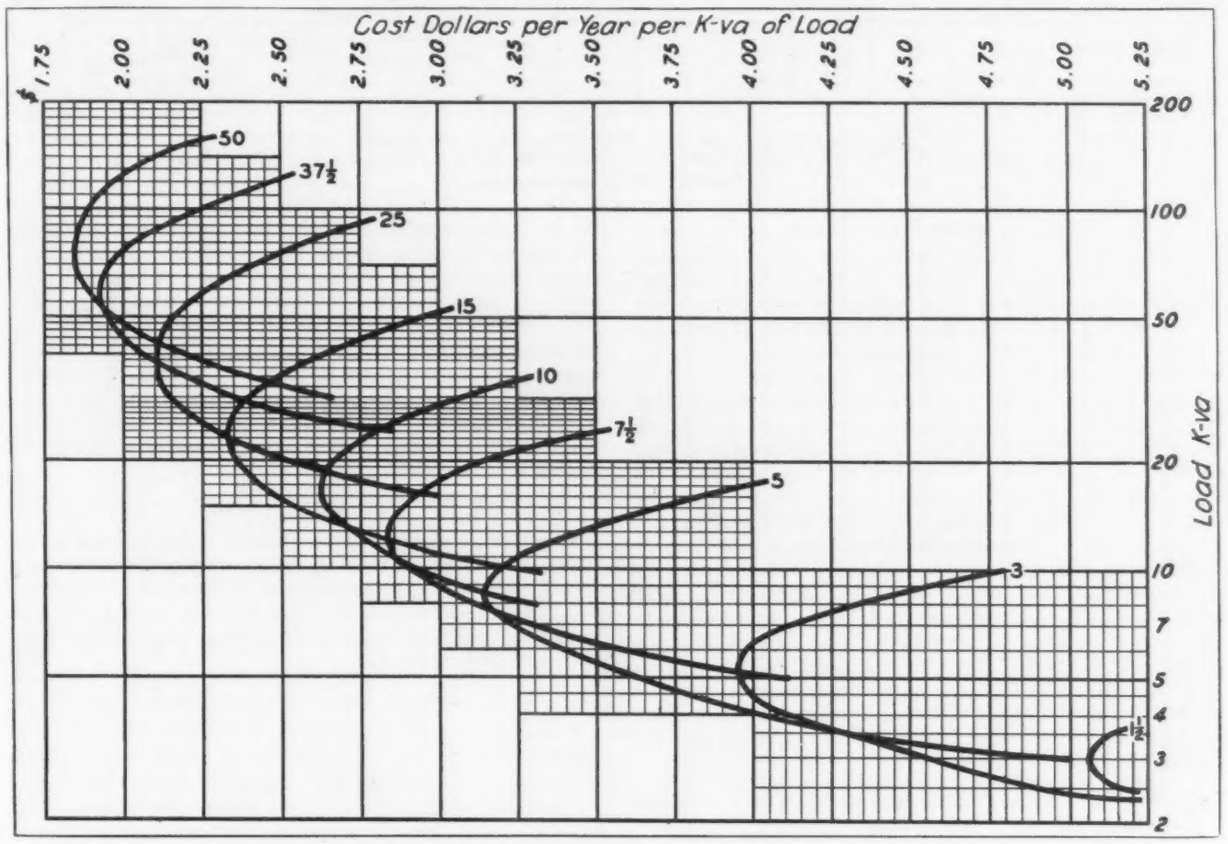


*Fig. 1. Annual cost per kva. for single-phase, 60-cycle, O.I.S.C., pole-type transformers set singly for two or three-wire service. High voltage 2300/4000-volt—low voltage 115/230 volt. A separate curve is shown for each standard size of transformer.*

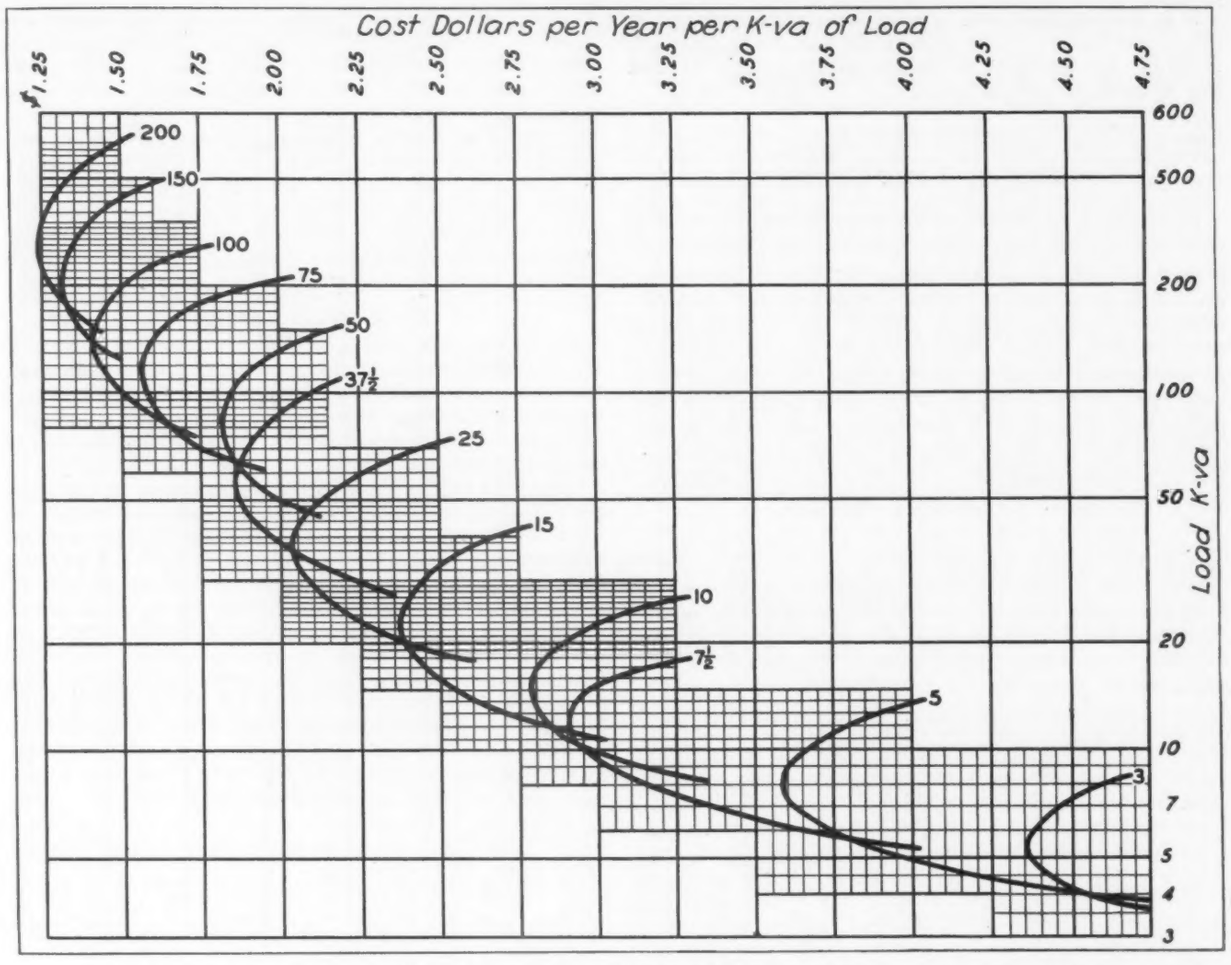


*Fig. 2. Annual cost per kva. for single-phase, 60-cycle, O.I.S.C. pole-type transformers set in symmetrical three-phase banks for power supply. High voltage 6,900 to 115/230 or 230/460 delta. A separate curve is shown for each standard size of transformer.*

### Transformer Performance

It might be well briefly to review some fundamental facts known about transformer performance that both the designer and user of transformers must not fail to consider.

*Temperature Rise.*—The amount of load any transformer will carry is limited by the temperature at which the installation will commence to deteriorate. This point is fixed by A.I.E.E. rules at 95 deg. C., which is equivalent to a 55-deg. C. rise above ambient temperatures of 40 deg. C. A well balanced design will have the losses so proportioned that heat liberated at rated load will not raise the temperature of the mass of oil to a point beyond which the cooling means provided will be unable to maintain this just below the specified 55-deg. C. rise. This definitely places the transformer in the class of apparatus whose nameplate rating is that of maximum continuous duty. Any other load but the rated load applied to a transformer will result in changes in efficiency, regulation, or temperature that may range from uneconomic to unsafe. Extraneous factors such as seasonal or daily short time duration of overload, seasonal or even daily reductions of ambient temperatures may be advantageously used to offset these theoretically uneconomic and unsafe results.

### Principal Phases of the Subject

A study of the duty and ambient temperature cycles of the transformer then becomes one of the principal phases of the subject of the loading of transformers. Another principal phase of this subject consists of the effect of load on the quality of regulation or inherent voltage drop within the transformer as a function of the amount and periodicity of change in amount of load. This assumes that appropriate limits of regulation are applied to associated primary supply and secondary service lines so that the transformer will not be burdened with an uneconomic share of this duty. The last important phase of this subject is the application of the pertinent values of energy costs, demand charges, and fixed rates of return, covering interest, depreciation, and taxes that are peculiar to the utility system upon whose lines the transformer is to be placed.

### Accuracy of Data

To avoid publication of confidential data, any figures or tables appearing in this report have been modified from actual data, specific guarantees of performance, or detailed costs except where the same are common knowledge, such as A.I.E.E. rules or extracts from other reports that have been previously published.

### Most Favorable Loading

The most favorable loading of transformers is that load which applied to the transformer will result in the lowest operating cost. Neglecting regulation for the moment, this can be obtained by capitalizing the losses. The methods used and the values taken for rates of return on investment, cost of energy, and demand charges vary with each system and sometimes within the subdivision of a large system especially if either loosely interconnected or composed of subdivisions

not contiguous. The mathematical equations can usually be written in such form that the customary device of equating the first derivative to zero will give maximum and minimum values. See illustrative examples appended.

Distribution transformers in general use and of so-called standard design have the losses proportioned to meet the designers' experience in capitalizing these losses, so that economical ratings much above the rated capacity of the transformer should be found only in the minority of cases, and any system finding that this is not true, i. e., finding an economical rating well above nameplate rating should have special or unusual circumstances such as low investment charges, high load factor, low energy and demand charges or particularly low factors affecting the capitalizing of the copper losses. Such a system might be one having low cost hydro-electric developments close to the load center or low cost but highly economical fuel plants using cheap fuel and likewise near the load center or some combination of both types.

### Loading Considering Regulation

It is a more complex problem to evaluate or capitalize the cost of regulation. Inherent regulation from the power source down to the distribution transformer is habitually compensated by external regulatory apparatus. Exciters, boosters, induction regulators, condensers, tap-changers, etc., are found at generating, switching, and important load centers, and the expenditures for this equipment are commonly accepted as in accord with good economics and good engineering.

The inherent regulation of the transformer is a function of the impedance of the windings and consequently is affected by all variations in the current passing through the coils. The current in turn is affected by the magnitude and power factor of the load and the regulation of the supplied voltage. Thus it is found that the regulation varies directly as the load; inversely as the supply voltage; and vectorially as the power factor of the load. This means that the supply voltage should be regulated within very narrow limits and that careful consideration should be given to the power factor of inductive loads in order to obtain even rated performance of the inherent regulation of the transformer. Transformers designed for voltages of 7,500 and up will have higher reactance due to space required for heavier insulation and consequently their inherent regulation will be greater (poorer) and more sensitive to lower (poorer) power factor. Likewise the cost per kva. of the higher voltage transformer being greater, the importance of savings in installed capacity is likewise greater. Consequently it follows that the economics of the regulation of the distribution transformer is likewise worthy of careful investigation.

### Standard Lines of Transformers

Any standard line of transformers should be applicable to all usual types of installation, such as (1) individually supplying single-phase domestic lighting, heating, and appliances, (2) banked symmetrically in closed or open star or delta and supplying mixed lighting and power loads, (3) banked symmetrically to supply pure power loads, or (4) special applications to supply loads such as X-rays, phase conversion, etc.

Obviously, then, it becomes desirable for any operating utility to formulate regulations for the proper application of standard transformers as a function of the characteristics of the load supplied rather than to impose specifications that would force manufacturers to supply a wide range of transformer characteristics within each rating and voltage class. No specific rules resulting from the actions of any group or committee such as this can be expected here, but methods of making up specific rules may be discussed here as a guide to their formulation.

### Tables for Specific Classes of Transformers and Loads

It may be said in general that rules for determining the size of a transformer for a particular load should first be divided into:

Transformers by type—pole type, subway, network, special types.
Within each type, by voltage class, primary and secondary.
That is 2,300/4,000 y 230/115
11,500 2,400
etc.

Loads by character:
- Lighting, single-phase.
- Lighting and heating.
- Lighting and small power.
- Power, urban customers.
- Power, suburban customers.
- Power, agricultural customers.
- Combined network.

Table I gives some statistics showing the relative number and kva. of single-phase transformers found in the 2,300 and 4,000-volt classes on the feeders in twelve substation areas in San Francisco, Sacramento, Oakland, Berkeley, San Diego, Alhambra, and Beverly Hills on lines of the Pacific Gas and Electric Company, Southern California Edison Company Ltd., Los Angeles Gas and Electric Corporation, and San Diego Consolidated Gas & Electric Company.

Table II shows the relative number and kva. of single-phase transformers installed by voltage class on one large system in the past eight years.

TABLE I

| Area and Voltage of Feeders | 2,300-Volt Single-Phase | | | | | | | | | | 4,000-Volt | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Set Single Phase | | In Combination Banks For Light and Power, 2-Phase, Etc. | | | | Set in 3-Phase Banks | | | | Set Single Phase | |
| | | | Main Transf. | | Assoc. Transf. | | Symmetrically | | Unsymmetrically | | | |
| | No. | Kva. | No. | Kva. | No. | Kva. | No. | Kva. | No. | Kva. | No. | Kva. |
| 4 kv. to 1st and 2nd residential | 261 | 6,105 | 64 | 2,240 | 78 | 705 | 42 | 2,777 | 3 | 40 | 0 | 0 |
| 4 kv. to 2nd res., lt. and hvy. ind. | 175 | 2,018 | 74 | 1,074 | 78 | 600 | 117 | 3,084 | 18 | 173 | 2 | 125 |
| 4 kv. to 1st and 2nd res. and lt. ind. | 462 | 7,398 | 52 | 1,022 | 52 | 431 | 126 | 5,081 | 66 | 1,538 | 0 | 0 |
| 4 kv. to 2nd res., lt. and hvy. ind. | 271 | 2,440 | 61 | 743 | 61 | 326 | 174 | 4,024 | 45 | 870 | 14 | 58 |
| 4 kv. to 2nd res., lt. and hvy. ind. | 449 | 7,031 | 45 | 840 | 45 | 295 | 180 | 6,494 | 54 | 874 | 0 | 0 |
| 4 kv. to 1st and 2nd residential | 25 | 583 | 37 | 350 | 37 | 105 | 39 | 1,159 | 0 | 0 | 0 | 0 |
| 4 kv. to 2nd res. and suburban | 98 | 611 | 25 | 225 | 25 | 100 | 27 | 389 | 0 | 0 | 0 | 0 |
| 2.3 kv. to 1st and 2nd res. and lt. ind. | 156 | 1,621 | 29 | 651 | 28 | 325 | 64 | 1,600 | 3 | 35 | 0 | 0 |
| 2.3 kv. to 2nd res. and lt. ind. | 196 | 1,848 | 67 | 681 | 67 | 341 | 85 | 1,490 | 120 | 1,045 | 0 | 0 |
| 4 kv. to 2nd res., lt. and hvy. ind. | 507 | 3,043 | ... | .... | .... | .... | 234 | 910 | 108 | 533 | 0 | 0 |
| 4 kv. to 1st and 2nd residential | 658 | 6,987 | 77 | 1,010 | 77 | 510 | 75 | 1,389 | 42 | 591 | 0 | 0 |
| 4 kv. to 1st and 2nd residential | 364 | 2,895 | 42 | 560 | 42 | 270 | 15 | 360 | 0 | 0 | 0 | 0 |
| Total | 3,622 | 42,580 | 573 | 9,396 | 590 | 4,008 | 1,178 | 28,757 | 459 | 5,699 | 16 | 183 |
| Grand Total | | | | No. 6,422—90,440 kva. | | | | | | | 16 | 183 |
| Per Cent of Grand Total | 56.4 | 47.3 | 9.0 | 10.4 | 9.2 | 4.5 | 18.3 | 31.6 | 7.1 | 6.2 | 100 | 100 |
| Average Size kva. | 11.7 | | 16.4 | | 7.0 | | 24.5 | | 12.4 | | 11.4 | |

**TABLE II**

Total Transformers Installed 1922 to 1929, both inclusive

| Type | Class | No. | Kva. | Average Size | Percent of Total No.* | Percent of Total Kva.* |
|---|---|---|---|---|---|---|
| Pole | 2,300 | 17,755 | 251,175 | 14.1 | 59.9* | 70.3* |
| | 4,000 | 2,164 | 15,100 | 7.0 | 7.2* | 4.2* |
| | 6,900 | 6,434 | 60,925 | 9.6 | 21.6* | 17.0* |
| | 11,500 | 3,356 | 30,500 | 9.1 | 11.3* | 8.5* |
| Total | ..... | 29,709 | 357,700 | 12.0 | 100.0* | 100.0* |
| Subway | 2,300 | 673 | 36,450 | 54.5 | 100.0** | 100.0** |
| Pole and Subway | ..... | 30,382 | 394,150 | 13.0 | ..... | ..... |

*Percent of total pole type only.
**Percent of total subway type only.

**Table III**

| Size kva. | Load Kw. | Per Cent Drop (Regulation) In Transformer | In Service | Total |
|---|---|---|---|---|
| A—For practically the same load on each transformer, viz. 4.5 to 4.6 kw. | | | | |
| 3 | 4.5 | 3.2 | 0.6 | 3.8 |
| 5 | 4.6 | 1.8 | 0.8 | 2.6 |
| B—For practically the same per cent overload, respectively 6 and 10 kw. | | | | |
| 3 | 6.0 | 4.6 | 0.5 | 5.1 |
| 5 | 10.0 | 3.8 | 2.2 | 6.0 |

**TABLE IV**

| Size kva. | Losses (watts) Iron | Copper | Total | Regulation % At 1.0 Power Factor | At 0.8 Power Factor | Efficiency % |
|---|---|---|---|---|---|---|
| 3* | 28 | 68 | 96 | 2.5 | 3.2 | 96.8 |
| 5* | 36 | 106 | 142 | 2.25 | 3.1 | 97.2 |
| Performance for Load of 4.5 kw. | | | | | | |
| 3 | 28 | 153 | 181 | 3.75 | 4.8 | 94.3 |
| 5 | 36 | 86 | 122 | 2.02 | 2.8 | 97.6 |
| Performance for 100% Overload | | | | | | |
| 3 | 28 | 272 | 300 | 5.0 | 6.4 | 90.0 |
| 5 | 36 | 424 | 460 | 4.5 | 6.2 | 90.8 |

*Performance for full load.

**TABLE V**

| Size Kva. | Percent Over Voltage | Loss (watts) Iron | Copper | Total | Regulation Percent At 1.0 Power Factor | At 0.8 Power Factor | Efficiency Percent |
|---|---|---|---|---|---|---|---|
| A—For Load of 4.5 kw. | | | | | | | |
| 3 | 8.0 | 32 | 131 | 163 | 3.45 | 4.45 | 94.6 |
| 5 | 5.5 | 38 | 77 | 115 | 1.9 | 2.65 | 97.7 |
| B—For 100% Overload | | | | | | | |
| 3 | 4.5 | 30 | 250 | 280 | 4.8 | 6.1 | 90.7 |
| 5 | 9.0 | 43 | 388 | 431 | 4.1 | 5.7 | 91.4 |

**TABLE VI**

| Size Kva. | 2,300-volt Class Losses—watts Fe. | Cu. | Total | Regulation Percent 1.0 | 0.8 | 6,900-volt Class Losses—watts Fe. | Cu. | Total | Regulation Percent 1.0 | 0.8 | 11,500-volt Class Losses—watts Fe. | Cu. | Total | Regulation Percent 1.0 | 0.8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2½ | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 34 | ... | ... | ... | ... |
| | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 75 | ... | ... | ... |
| | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 109 | ... | ... |
| | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3.0 | ... |
| | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3.5 |
| 3 | 28 | ... | ... | ... | ... | 30 | ... | ... | ... | ... | ..... | ... | ... | ... | ... |
| | ... | 68 | ... | ... | ... | ... | 85 | ... | ... | ... | ... | ... | ... | ... | ... |
| | ... | ... | 96 | ... | ... | ... | ... | 115 | ... | ... | ... | ... | ... | ... | ... |
| | ... | ... | ... | 2.5 | ... | ... | ... | ... | 2.9 | ... | ... | ... | ... | ... | ... |
| | ... | ... | ... | ... | 3.2 | ... | ... | ... | ... | 3.6 | ... | ... | ... | ... | ... |
| 5 | 36 | ... | ... | ... | ... | 44 | ... | ... | ... | ... | 48 | ... | ... | ... | ... |
| | ... | 106 | ... | ... | ... | ... | 130 | ... | ... | ... | ... | 132 | ... | ... | ... |
| | ... | ... | 142 | ... | ... | ... | ... | 174 | ... | ... | ... | ... | 180 | ... | ... |
| | ... | ... | ... | 2.25 | ... | ... | ... | ... | 2.7 | ... | ... | ... | ... | 2.7 | ... |
| | ... | ... | ... | ... | 3.1 | ... | ... | ... | ... | 4.1 | ... | ... | ... | ... | 4.1 |
| 7½ | 48 | ... | ... | ... | ... | 58 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | ... | 150 | ... | ... | ... | ... | 175 | ... | ... | ... | ... | ... | ... | ... | ... |
| | ... | ... | 198 | ... | ... | ... | ... | 233 | ... | ... | ... | ... | ... | ... | ... |
| | ... | ... | ... | 2.0 | ... | ... | ... | ... | 2.4 | ... | ... | ... | ... | ... | ... |
| | ... | ... | ... | ... | 2.6 | ... | ... | ... | ... | 3.3 | ... | ... | ... | ... | ... |
| 10 | 57 | ... | ... | ... | ... | 70 | ... | ... | ... | ... | 80 | ... | ... | ... | ... |
| | ... | 190 | ... | ... | ... | ... | 220 | ... | ... | ... | ... | 215 | ... | ... | ... |
| | ... | ... | 247 | ... | ... | ... | ... | 290 | ... | ... | ... | ... | 295 | ... | ... |
| | ... | ... | ... | 1.9 | ... | ... | ... | ... | 2.3 | ... | ... | ... | ... | 2.3 | ... |
| | ... | ... | ... | ... | 2.6 | ... | ... | ... | ... | 3.1 | ... | ... | ... | ... | 3.3 |

**Table VII**

| Size kva. | Load kva. | Load Per cent Rating | Annual Cost per kva. | Regulation per cent at 1.0 Power Factor | Regulation per cent at 0.8 Power Factor |
|---|---|---|---|---|---|
| | 0.5 | 33⅓ | $15.30 | 1.0 | 1.0 |
| | 0.75 | 50 | 10.60 | 1.6 | 1.6 |
| 1½ | 1.0 | 66⅔ | 8.35 | 2.1 | 2.1 |
| | 1.5 | 100 | 6.25 | 3.1 | 3.1 |
| | 2.0 | 133⅓ | 5.45 | 4.1 | 4.1 |
| | 2.5 | 166⅔ | 5.15 | 5.2 | 5.2 |
| | 2.5 | 83⅓ | 5.15 | 2.1 | 2.7 |
| 3.0 | 3.0 | 100 | 4.60 | 2.5 | 3.2 |
| | 4.0 | 133⅓ | 4.15 | 3.3 | 4.2 |
| | 4.2 | 140 | 4.10 | 3.5 | 4.3 |
| | 4.2 | 84 | 4.10 | 1.9 | 2.6 |
| | 5.0 | 100 | 3.65 | 2.25 | 3.1 |
| 5.0 | 6.0 | 120 | 3.40 | 2.7 | 3.7 |
| | 7.0 | 140 | 3.26 | 3.15 | 4.3 |
| | 7.3 | 146 | 3.22 | 3.3 | 4.5 |
| | 7.3 | 97½ | 3.22 | 1.95 | 2.5 |
| 7.5 | 7.5 | 100 | 3.12 | 2.0 | 2.6 |
| | 10.0 | 133⅓ | 2.90 | 2.7 | 3.5 |
| | 10.05 | 134 | 2.88 | 2.7 | 3.5 |
| | 10.0 | 100 | 2.94 | 1.9 | 2.6 |
| 10.0 | 10.05 | 100½ | 2.88 | 1.9 | 2.6 |
| | 12.5 | 125 | 2.71 | 2.4 | 3.2 |
| | 14.0 | 140 | 2.65 | 2.7 | 3.6 |
| | 14.0 | 93⅓ | 2.65 | 1.7 | 2.7 |
| 15.0 | 15.0 | 100 | 2.55 | 1.8 | 2.9 |
| | 20.0 | 133⅓ | 2.35 | 2.4 | 3.9 |
| | 24.0 | 160 | 2.32 | 2.9 | 4.6 |
| | 24.0 | 96 | 2.32 | 1.5 | 2.8 |
| 25.0 | 25.0 | 100 | 2.28 | 1.6 | 2.9 |
| | 37.5 | 150 | 2.09 | 2.4 | 4.4 |
| 37.5 | 37.5 | 100 | 2.09 | 1.4 | 3.0 |
| | 58.0 | 155 | 1.91 | 2.2 | 4.6 |
| | 50.0 | 100 | 2.00 | 1.3 | 2.9 |
| 50.0 | 58.0 | 116 | 1.91 | 1.5 | 3.4 |
| | 75.0 | 150 | 1.83 | 1.95 | 4.4 |

**Table VIII**

| Size kva. | Load kva. | Load Per Cent Rating | Annual Cost Per kva. | Regulation Per Cent at 1.0 Power Factor | Regulation Per Cent at 0.8 Power Factor |
|---|---|---|---|---|---|
| 1½ | 0.50 | 33⅓ | $15.30 | 1.0 | 1.0 |
| | 2.15 | 143 | 5.35 | 3.0 | 3.0 |
| 3.0 | 2.15 | 72 | 5.55 | 1.8 | 2.3 |
| | 3.60 | 120 | 4.25 | 3.0 | 3.85 |
| 5.0 | 3.60 | 72 | 4.50 | 1.95 | 2.65 |
| | 5.55 | 111 | 3.50 | 3.0 | 4.1 |
| 7.5 | 5.55 | 74 | 3.85 | 1.5 | 1.9 |
| | 11.25 | 150* | 2.86 | 3.0 | 3.9 |
| 10.0 | 11.25 | 112½ | 2.82 | 2.1 | 2.9 |

*Exceeds most economical rating.

**Table IX**

2,300-volt single-phase transformers on lighting and heating loads.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Load kva..... | ½ | 2 | 3½ | 5½ | 10 | 15 | 25 | 37½ | 58 |
| (Not continuous— | to | to | to | to | to | to | to | to | to |
| see note.) | 2 | 3½ | 5½ | 10 | 15 | 25 | 37½ | 58 | 75 |
| Size Transformer.. | 1½ | 3 | 5 | 7½ | 10 | 15 | 25 | 37½ | 50 |

**Note:**—For loads of not more than four hours peak duration followed by four hours or more at less than 50% average of the applied load.

## Value of Loading Rules

Any set of rules would be made useful by the provision of a simple, easily understandable set of directions whereby a foreman of average experience or a district office estimator could readily select the proper capacity of a transformer, given the general characteristics of the load and supply. All important loads should have the selection of their transformers checked by more experienced or responsible personnel. The value of any such rules should be to reduce the installed kva. of transformers without increasing the annual charges or decreasing the standard of regulation maintained at the customer's service switch.

## Previous Reports

In previous reports, one phase of the above subject has been covered as follows:

> Accordingly, the work has been confined entirely to the study of the loading of the smaller distribution transformers and particularly those supplying service to lights combined with electric ranges and water-heaters, together with a small amount of air heating, but not including service to residences entirely heated electrically.

This is but a portion of one of the seven subdivisions mentioned above and covers but one voltage class.

This earlier report is an excellent contribution to its phase of the whole problem and contains data in perfect agreement with the fundamental theories of transformer design and performance. In order to analyze some of the data in this report, a comparison of the 3 and 5-kv. types, with respectively No. 2 and No. 8 secondaries as suggested, is shown in Table III.

A comparison of these two transformers using guaranteed performance data is shown in Table IV.

Note that the recorded regulation is slightly better (less) than the guarantees. If this be due to a primary voltage slightly above normal, then the losses should have been as shown in Table V.

To evaluate results in Tables III, IV, and V, duration of the load and the capitalized values in detail must be known and considered. Note that these loads are non-inductive. For inductive loads the regulation would be excessive on overloads except at severe overvoltage in which case the efficiency is correspondingly reduced.

Table VI shows the characteristics of similar ratings in different voltage classes.

It can be readily seen that the limits within which efficiency and regulation may be sacrificed for advantages resulting in overloading transformers, are narrowed in the higher voltage classes, where, due to the higher unit costs of these transformers, the maximum savings could be expected.

Recalling that the foregoing are just a few specific cases within but five sizes out of twelve and one voltage class out of five, it is obvious that a thorough analysis of this subject will involve a truly enormous amount of detailed study.

## Illustrative Examples

A few years ago a member of this subcommittee found it desirable to determine the most economical rating of a standard line of distribution transformers and the method pursued was as follows:

**TABLE X**

6,900-Volt Single-Phase Transformers in 3-Phase Banks for Power

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Load Kva..... | ½ | 3 | 6 | 8 | 11 | 25 | 27 | 43 | 60 | 95 | 120 | 185 |
| per Phase | to | to | to | to | to | to | to | to | to | to | to | to |
| (See Note) | 3 | 6 | 8 | 11 | 18 | 27 | 43 | 60 | 95 | 120 | 185 | 250 |
| Size Transformer..... | 3 | 5 | 7.5 | 10 | 15 | 25 | 37.5 | 50 | 75 | 100 | 150 | 200 |

Note: 1. For single motor applications starting conditions must be considered.
2. For conversion of total connected hp. to kva. per phase, see text.

**TABLE XI**

Most Economical Rating for Single-Phase Loads; 2,300-volt Single-Phase, 60-cycle, Pole-Type Transformers. See Column Q.

| Size Kva. | Refer to Text for Meaning of Letters Below | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | DP | GF | A=DP+GF | 2A | B | $Q=\sqrt{\frac{A}{B}}$ | L kva. | $\frac{2A}{L}$ |
| 1½ | $ 6.20 | $1.25 | $ 7.45 | $14.90 | $1.95 | 1.96 | 2.94 | $5.08 |
| 3 | 8.70 | 1.70 | 10.40 | 20.80 | 3.35 | 1.76 | 5.28 | 3.95 |
| 5 | 11.40 | 2.30 | 13.70 | 27.40 | 4.55 | 1.75 | 8.75 | 3.13 |
| 7½ | 14.70 | 3.05 | 17.75 | 35.50 | 6.30 | 1.68 | 12.6 | 2.82 |
| 10 | 17.65 | 3.70 | 21.35 | 43.70 | 8.00 | 1.63 | 16.3 | 2.62 |
| 15 | 22.30 | 5.00 | 27.30 | 54.60 | 11.00 | 1.57 | 23.35 | 2.32 |
| 25 | 33.45 | 7.20 | 40.65 | 81.30 | 16.35 | 1.57 | 39.25 | 2.09 |
| 37½ | 46.25 | 9.70 | 55.95 | 111.90 | 23.05 | 1.56 | 58.5 | 1.91 |
| 50 | 56.75 | 12.35 | 69.10 | 138.20 | 30.25 | 1.51 | 75.5 | 1.83 |

**TABLE XII**

Most Economical Rating for 3-Phase Loads; 6,900-Volt, Single-Phase, 60-Cycle, Pole-Type Transformers, Set in 3-Phase Banks. See Column Q.

| Size kva. Per Phase | Mounted on | Primary Fitted With | Refer to Text for Meaning of Letters Below | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | DP | GF | A | 2A | B | Q | L kva. | $\frac{2A}{L}$ |
| 3 | Pole | Cutouts | $ 10.00 | $1.80 | $ 11.80 | $ 23.60 | $ 3.60 | 1.81 | 5.43 | $ 4.37 |
| 5 | " | " | 12.00 | 2.64 | 14.64 | 29.28 | 5.46 | 1.64 | 8.2 | 3.57 |
| 7½ | " | " | 14.55 | 3.42 | 17.97 | 35.94 | 6.60 | 1.65 | 12.4 | 2.89 |
| 10 | " | " | 16.94 | 4.26 | 21.20 | 42.40 | 9.14 | 1.52 | 15.2 | 2.79 |
| 15 | " | " | 21.20 | 5.52 | 26.72 | 53.44 | 11.72 | 1.51 | 22.6 | 2.36 |
| 25 | " | " | 29.25 | 8.40 | 37.65 | 75.30 | 17.20 | 1.48 | 37.0 | 2.03 |
| 37½ | " | 3P. Sw. Fse. | 40.90 | 12.00 | 52.90 | 105.80 | 22.68 | 1.52 | 57.2 | 2.02 |
| 50 | Platf. | " | 56.60 | 16.20 | 72.80 | 145.60 | 28.14 | 1.60 | 80.0 | 1.82 |
| 75 | " | " | 66.90 | 23.10 | 90.00 | 180.00 | 37.80 | 1.54 | 115.5 | 1.56 |
| 100 | " | " | 72.00 | 27.60 | 99.60 | 199.20 | 51.62 | 1.39 | 139.0 | 1.43 |
| 150 | " | " | 93.00 | 42.00 | 135.00 | 270.00 | 72.50 | 1.36 | 205.0 | 1.32 |
| 200 | Pad | " | 106.80 | 54.00 | 160.80 | 321.60 | 94.50 | 1.30 | 261.0 | 1.23 |

*Neglecting Regulation.* The most economical rating is that ratio of load to rated capacity at which the annual charges are found to be at a minimum. The method used indicated that this rating corresponded to the load wherein the fixed charges were exactly equal to the variable charges due to the variation in copper losses. The mathematics of this method follows:

### Annual Cost of Transformers

Let C = total annual cost at any specified load (L).
P = total cost installed.
F = core losses in watts.
W = copper losses in watts at full load.
L = kva. load.
K = kva. rating.

$Q = \frac{L}{K}$ at most economical rating by equating $\frac{dC}{dL} = 0$.

and

H = annual cost of 1 watt-yr. of copper loss.
G = annual cost of 1 watt-yr. of core loss.
D = rate of fixed charges applicable to P.

From:

Total annual cost = D (total cost installed) + G (core loss watts) + H (copper loss, watts $\left(\frac{\text{load}}{\text{rating}}\right)^2$

may be written: $C = DP + GF + HW\left(\frac{L}{K}\right)^2$ (1)

Simplify by lettering:

The fixed charges $(DP + GF) = A$ (2)

and the variable charges $HW\left(\frac{L}{K}\right)^2 = B\left(\frac{L}{K}\right)^2$ (3)

and substituting in (1), then: $C = A + B\left(\frac{L}{K}\right)^2$ (4)

Divide both sides of (4) by L then: $\frac{C}{L} = \frac{A}{L} + \frac{BL}{K^2}$ (5)

Differentiate C in respect to L then: $\frac{dC}{dL} = \frac{-A}{L^2} + \frac{B}{K^2}$ (6)

Solve for maxima and minima by equating (6) to zero then:

$$\frac{-A}{L^2} + \frac{B}{K^2} = 0$$

$$\frac{B}{K^2} = \frac{A}{L^2}$$

$$\left(\frac{L}{K}\right)^2 = \frac{A}{B} \quad (7)$$

$$\frac{L}{K} = \sqrt{\frac{A}{B}} = Q \quad (8)$$

Substitute (7) in (4) then: $C = A + B\left(\frac{A}{B}\right) = A + A = 2A$ (9)

Divide (9) by L to obtain the annual cost per kva. at Q, then:

$$\text{Annual cost at most economical rating} = \frac{2A}{L} \quad (10)$$

Tables XI and XII illustrate the results of calculations as above for the 2,300 and 6,900-volt classes respectively.

The values in Tables VII, XI, XII, and XIII are plotted graphically in Figs. 1 and 2. Note that these curves constitute a family of interesting parabolas and that in practically every size a lower annual cost per kva. can be obtained by using the next larger size transformer long before the most economical rating is reached. Tables VII and XIII have been reported to show only those ratings that fall within

**Table XIII**

| Size kva. | Load kva. | Load Per Cent Rating | Annual Cost Per kva. | Regulation Per Cent at 1.0 Power Factor | Regulation Per Cent at 0.8 Power Factor |
|---|---|---|---|---|---|
| | 0.50 | 16.7 | $23.80 | 0.50 | 0.83 |
| | 0.75 | 25.0 | 16.10 | 0.75 | 1.25 |
| | 1.00 | 33.3 | 12.20 | 1.00 | 1.67 |
| 3 | 1.50 | 50.0 | 8.46 | 1.50 | 2.50 |
| | 2.00 | 66.7 | 6.69 | 2.00 | 3.33 |
| | 3.00 | 100.0 | 5.13 | 2.95 | 5.00 |
| | 4.00 | 133.0 | 4.57 | 3.95 | 6.67 |
| | 4.00 | 80.0 | 4.54 | 2.04 | 3.36 |
| 5 | 5.00 | 100.0 | 4.02 | 2.65 | 4.20 |
| | 6.00 | 120.0 | 3.75 | 3.06 | 5.04 |
| | 6.00 | 80.0 | 3.70 | 1.96 | 3.64 |
| | 7.00 | 93.5 | 3.61 | 2.29 | 4.25 |
| | 7.50 | 100.0 | 3.27 | 2.45 | 4.55 |
| 7½ | 8.00 | 107.0 | 3.18 | 2.61 | 4.85 |
| | 8.25 | 110.0 | 3.15 | 2.69 | 5.00 |
| | 9.00 | 120.0 | 3.05 | 2.94 | 5.46 |
| | 10.00 | 133.0 | 2.97 | 3.26 | 6.07 |
| | 11.00 | 147.0 | 2.93 | 3.60 | 6.68 |
| 10 | 11.00 | 110.0 | 2.94 | 2.53 | 5.06 |
| | 12.00 | 120.0 | 2.87 | 2.76 | 5.52 |
| | 12.00 | 80.0 | 2.85 | 1.60 | 3.36 |
| | 14.00 | ..... | 2.70 | 1.87 | 3.92 |
| 15 | 15.00 | 100.0 | 2.56 | 2.00 | 4.20 |
| | 16.00 | ..... | 2.50 | 2.14 | 4.48 |
| | 18.00 | ..... | 2.42 | 2.40 | 5.04 |
| | 20.00 | ..... | 2.38 | 2.67 | 5.60 |
| | 20.00 | 80.0 | 2.43 | 1.44 | 3.68 |
| | 22.50 | 90.0 | 2.29 | 1.62 | 4.14 |
| | 25.00 | 100.0 | 2.18 | 1.80 | 4.60 |
| 25 | 27.50 | 110.0 | 2.13 | 1.98 | 5.06 |
| | 30.00 | 120.0 | 2.08 | 2.16 | 5.52 |
| | 32.50 | 130.0 | 2.05 | 2.24 | 5.96 |
| | 35.00 | 140.0 | 2.04 | 2.52 | 6.43 |
| | 35.00 | 93.3 | 2.08 | 1.38 | 3.77 |
| | 37.50 | 100.0 | 2.02 | 1.49 | 4.06 |
| 37½ | 40.00 | 107.0 | 1.97 | 1.60 | 4.35 |
| | 43.00 | 114.5 | 1.92 | 1.71 | 4.64 |
| | 45.00 | 120.0 | 1.90 | 1.83 | 5.00 |
| | 50.00 | 133.0 | 1.87 | 1.92 | 5.21 |
| 50 | 50.00 | 100.0 | 2.02 | 1.50 | 4.15 |
| | 60.00 | 120.0 | 1.89 | 1.80 | 4.97 |
| | 60.00 | 80.0 | 1.90 | 1.08 | 3.12 |
| | 70.00 | 93.5 | 1.76 | 1.26 | 3.64 |
| | 75.00 | 100.0 | 1.70 | 1.35 | 3.90 |
| 75 | 80.00 | 107.0 | 1.66 | 1.44 | 4.16 |
| | 90.00 | 120.0 | 1.59 | 1.62 | 4.68 |
| | 96.00 | 128.0 | 1.57 | 1.73 | 5.00 |
| | 100.00 | 133.0 | 1.56 | 1.80 | 5.20 |
| | 96.00 | 96.0 | 1.53 | 1.30 | 3.07 |
| | 100.00 | 100.0 | 1.51 | 1.35 | 3.94 |
| | 110.00 | 110.0 | 1.48 | 1.49 | 4.10 |
| 100 | 112.50 | 112.5 | 1.47 | 1.52 | 4.51 |
| | 122.00 | 122.0 | 1.44 | 1.65 | 4.61 |
| | 130.00 | 130.0 | 1.43 | 1.75 | 5.00 |
| | 139.00 | 139.0 | 1.39 | 1.88 | 5.33 |
| | 139.00 | 92.5 | 1.42 | 1.20 | 3.70 |
| | 150.00 | 100.0 | 1.38 | 1.30 | 4.00 |
| 150 | 162.50 | 108.0 | 1.36 | 1.41 | 4.33 |
| | 175.00 | 117.0 | 1.33 | 1.52 | 4.67 |
| | 187.50 | 125.0 | 1.32 | 1.63 | 5.00 |
| | 187.50 | 93.8 | 1.30 | 1.17 | 3.75 |
| 200 | 200.00 | 100.0 | 1.28 | 1.25 | 4.00 |
| | 250.00 | 125.0 | 1.23 | 1.56 | 5.00 |

these limits and to show in addition the regulation at the ratings tabulated.

*Considering Regulation.* Reference to the tables just discussed will reveal that the regulation resulting from many of the overload values shown is below any commonly accepted value of service. Tables VIII and XIV have been prepared limiting the loads applied to 3 per cent regulation at 1.0 power factor for Table VIII and 5 per cent regulation at 0.8 power factor for Table XIV.

Tables IX and X illustrate the simplified form that may be made up from the data in the foregoing tables. It must be recalled that the considerations of integrating the load are not covered in these tables.

### Each Utility to Prepare Own Tables

Each utility, after determining the limits of regulation and the cost factors for fixed charges, energy cost, and demand charges, could prepare for its own use similar tables for the various loads and transformer classes as outlined above.

**Table XIV**

| Size kva. | Load kva. | Load Per Cent Rating | Annual Cost Per kva. | Regulation Per Cent at 1.0 Power Factor | Regulation Per Cent at 0.8 Power Factor |
|---|---|---|---|---|---|
| | 1.00 | 33.3 | $12.20 | 1.00 | 1.67 |
| 3 | 2.00 | 66.7 | 6.69 | 2.00 | 3.33 |
| | 3.00 | 100.0 | 5.13 | 2.95 | 5.00 |
| | 3.00 | 60.0 | 5.53 | 1.59 | 2.52 |
| | 4.00 | 80.0 | 4.54 | 2.04 | 3.36 |
| 5 | 5.00 | 100.0 | 4.02 | 2.65 | 4.20 |
| | 6.00 | 120.0 | 3.75 | 3.06 | 5.04 |
| | 6.00 | 80.0 | 3.70 | 1.96 | 3.64 |
| 7½ | 7.50 | 100.0 | 3.27 | 2.45 | 4.55 |
| | 8.25 | 110.0 | 3.15 | 2.69 | 5.00 |
| | 8.25 | 82.5 | 3.34 | 1.82 | 3.64 |
| 10 | 10.00 | 100.0 | 3.03 | 2.30 | 4.60 |
| | 11.00 | 110.0 | 2.94 | 2.53 | 5.06 |
| | 11.00 | 73.5 | 3.00 | 1.47 | 3.08 |
| 15 | 15.00 | 100.0 | 2.56 | 2.00 | 4.20 |
| | 18.00 | 120.0 | 2.42 | 2.40 | 5.04 |
| | 18.00 | 72.0 | 2.59 | 1.30 | 3.31 |
| 25 | 25.00 | 100.0 | 2.18 | 1.80 | 4.60 |
| | 27.50 | 110.0 | 2.13 | 1.98 | 5.06 |
| | 27.50 | 73.3 | 2.36 | 1.15 | 3.19 |
| 37½ | 37.50 | 100.0 | 2.02 | 1.60 | 4.35 |
| | 43.00 | 114.5 | 1.92 | 1.83 | 5.00 |
| | 43.00 | 86.0 | 2.15 | 1.29 | 3.57 |
| 50 | 50.00 | 100.0 | 2.02 | 1.50 | 4.15 |
| | 60.00 | 120.0 | 1.89 | 1.80 | 4.97 |
| | 60.00 | 80.0 | 1.90 | 1.08 | 3.12 |
| 75 | 75.00 | 100.0 | 1.70 | 1.35 | 3.90 |
| | 96.00 | 128.0 | 1.59 | 1.73 | 5.00 |
| | 96.00 | 96.0 | 1.53 | 1.30 | 3.94 |
| 100 | 100.00 | 100.0 | 1.51 | 1.35 | 4.10 |
| | 122.00 | 122.0 | 1.44 | 1.65 | 5.00 |
| | 122.00 | 81.3 | 1.51 | 1.06 | 3.25 |
| 150 | 150.00 | 100.0 | 1.38 | 1.30 | 4.00 |
| | 187.50 | 125.0 | 1.32 | 1.63 | 5.00 |
| | 187.50 | 93.8 | 1.30 | 1.17 | 3.75 |
| 200 | 200.00 | 100.0 | 1.28 | 1.25 | 4.00 |
| | 250.00 | 125.0 | 1.23 | 1.56 | 5.00 |

### Committee Has No Confidential Data

It is not within the province of this committee to have or to publish basic limiting factors and costs and consequently without these it would be unable to prepare or publish detailed tables. However, tables prepared for use by utilities within this geographical subdivision could well be published and compared by the successors of this subcommittee.

## *Pole Line Structures**

*This subcommittee has not followed the subjects of last year's work, as final information on the results of the preservative treatment of test poles will not be available for several years, and it is too soon to expect even a report on condition to date.*

*The subjects attempted this year with the committee members covering them are as follows:*

*Guying requirements of G.O.64A are covered in a paper submitted by W. P. Champion, with a report of tests made on the system of the Southern California Edison Company and compiled by H. E. Jung, and a report on guy and conductor tensions on the system of The Southern Sierras Power Company, prepared by W. B. Loper.*

*Rate of deterioration of untreated poles is covered in a tabulation of results prepared by Ralph E. Hill.*

*Insulating guy and bond wires from ground wires*

* Report of subcommittee on pole line structures, overhead systems committee, Engineering Section. K. B. Ayres, chairman. E. R. Banks, R. G. Boyles, N. P. Carlsen, C. B. Carlson, S. L. Case, W. P. Champion, M. W. Clark, Clinton DeWitt, A. R. Fryklund, G. A. Hart, H. F. Hartzell, R. E. Hill, B. C. Holst, J. E. MacDonald, Joe Mini, J. B. Naugle, A. J. Pahl, J. C. Porter, E. Y. Porter, H. H. Shields, C. L. Yager.

*where they cross on poles is presented in a paper by N. P. Carlsen.*

*Steel vs. wood poles for distribution has been presented by Carlton L. Yager.*

*The effect of impact on transformer poles showing the results of impact of foreign bodies, as automobiles, striking transformer poles at various rates of speed, has been prepared by C. B. Carlson.*

A NUMBER of the companies have made tests of guy tension under various conditions and have compared the results with the present rules covering guying. The following reports cover a series of tests along these lines:

## *Guying Requirements of G.O. 64*[3]

*The following data and results were obtained in a recent series of tests made on the system of the Southern California Edison Company Ltd.*

THE poles included in the test were set at various times during the years 1923 to 1931. The actual tensions in the guys were measured by means of a tension indicator which did not require slacking off the guy, but gave a direct reading which, when referred to a calibration curve made up from tests, gave the actual tension in the guy.

The sags in the conductors were determined by the following formula:

$$d = 4.025\left(\frac{T}{2n}\right)^2, \text{ in which}$$

d = sag in feet,
T = total time of waves timed (out and back),
n = number of waves timed.

Three complete waves (out and back) were timed, thus reducing the formula to $d = 0.1118\ T^2$.

Having determined the sags of the various conductors by means of the formula just given, it is easy to determine the tensions and the resultant pull on the pole which must be balanced by the tension in the guy.

### Guying of Most Poles Too Heavy

This theoretical tension in the guy was found to be in most cases less than the actual tension in the guy, which means simply that the guying is too heavy—that is, that the guy is exerting sufficient stress actually to stress the pole as well as to balance the pull of the conductors. On the other hand, it is our theory that the opposite should be the case, that is, the average pole should and can support part of the pull of the conductors.

[3] Written for the subcommittee on pole line structures, overhead systems committee, Engineering Section, by H. E. Jung.

TABLE I

| Test No. | Year Set | Pound Tension in Guy — Indicated | Pound Tension in Guy — Required | Pound Stress on Pole | Pound Stress by Pole | Size Guy | Per Cent Stress Held by Pole |
|---|---|---|---|---|---|---|---|
| 1 | 1925 | 715 | 714.4 | Balanced | | ⅜ | .... |
| 2 | 1928 | 590 | 593.5 | Balanced | | ⅜ | .... |
| 3 | 1925 | 1120 | 1008.5 | 111.5 | ..... | ⅜ | .... |
| 4 | 1925 | 870 | 776.7 | 93.3 | ..... | ⅜ | .... |
| 5 | 1925 | 460 | 372.6 | 87.4 | ..... | ⅜ | .... |
| 6 | 1928 | 510 | 494.8 | 15.2 | ..... | ⅜ | .... |
| 7 | 1924 | 670 | 641.8 | 28.2 | ..... | ⅜ | .... |
| 8 | 1925 | 390 | 396.4 | Balanced | | ⅜ | .... |
| 9 | 1931 | 805 | 754.3 | 50.7 | ..... | ⅜ | .... |
| 10 | 1923 | 790 | 603.2 | 186.8 | ..... | ⅜ | .... |
| 11 | 1928 | 615 | 723.5 | ..... | 108.5 | ⅜ | 15.0 |
| 12 | 1923 | 730 | 597.4 | 132.6 | ..... | ⅜ | .... |
| 13 | 1923 | 600 | 567.5 | 32.5 | ..... | ⅜ | .... |
| 14 | 1929 | 1350 | 1249.0 | 101.0 | ..... | ⅜ | ..... |
| 15 | 1924 | 480 | 459.3 | 20.7 | ..... | ⅜ | .... |
| 16 | 1930 | Results Doubtful | | ..... | ..... | ⅜ | .... |
| 17 | 1924 | Results Doubtful | | ..... | ..... | ⅜ | .... |
| 18 | 1929 | 1750 | 2425.0 | ..... | 675.0 | ⅜ | 27.8 |
| 19 | 1930 | 1660 | 1435.8 | 224.2 | ..... | ⅜ | .... |
| 20 | 1930 | 1480 | 1695.2 | ..... | 215.2 | ⅜ | 12.7 |

The foregoing condition did not prevail in all the tests. For it was found that in some of the tests the condition of the pole actually supporting part of the conductor pull holds true. This is obvious, since the tension required in the guy by the pull of the conductors was greater than the tension actually found in the guy.

The results of the tests are given in Table No. 1.

### Size of Poles Used

The majority of the poles included in the tests were 40-ft. western red cedar poles; there were thirteen 40-ft. cedar poles out of twenty poles included in the tests. These thirteen 40-ft. poles had an average groundline circumference of 37.7 in., or an average diameter of 12 in. The average span length encountered was approximately 130 ft., and the conductors were all triple-braid weather-proof. In three cases the conductors were size No. 2 (A.W.G.), in four cases size No. 4, and in six cases size No. 6.

Table No. 2 gives data on the thirteen 40-ft. poles:

TABLE II

| Test No. | Circum. at Groundline (inches) | TBWP Size Conductor | Span Length (feet) | Guy Angle |
|---|---|---|---|---|
| 2 | 34 | No. 4 | 120.50 | 39°-24′ |
| 6 | 36 | No. 4 | 118.42 | 37°-16′ |
| 8 | 42 | No. 6 | 151.33 | 25°-43′ |
| 9 | 39 | No. 4 | 136.67 | 26°-47′ |
| 10 | 42 | No. 6 | 130.00 | 30°-05′ |
| 11 | 38 | No. 4 | 100.00 | 21°-51′ |
| 12 | 36 | No. 6 | 160.33 | 29°-07′ |
| 13 | 37 | No. 6 | 159.50 | 34°-05′ |
| 15 | 36 | No. 6 | 121.00 | 25°-59′ |
| 17 | 40 | No. 6 | 117.58 | 30°-37′ |
| 18 | 34 | No. 2 | 100.00 | 34°-21′ |
| *19 | 53 | No. 2 | 141.00 | 46°-33′ |
| 20 | 39 | No. 2 | 164.67 | 44°-29′ |
| Average | 37.7 | ..... | 131.7 | 31°-45′ |

*This pole not included in averages since it is obviously too large.

Since the 40-ft. cedar pole was the size and type most frequently encountered in these tests, only this size and type will be considered in this discussion. Lines built to withstand only light loading conditions will be considered. The fiber strength of western red cedar poles is given as 5,000 lb. per sq.in. by G.O. 64-A, and the factor of safety for wood poles in class "A" construction is given as 4 by G.O. 64-A. Thus the effective fiber strength of the poles will be 1,250 lb. per sq.in.

Our standards call for 40-ft. poles to be set 6 ft. 0 in. This gives an effective height of pole of 34 ft. 0 in. The average diameter at the top of pole will be considered to be 8 in. Since the conductors are dead-ended they will be considered effective at 8 in. below the top of pole, giving an effective conductor height of 33 ft. 4 in.

### Forces Tending to Break Pole

The principal forces tending to break a pole are wind pressures on pole and conductors when the wind blows transversely. These tend to break the pole by cross bending.

Let $M_1$ = moment of the wind on the pole,
$M_2$ = moment of the wind on the wires,
M = moment of resistance of the pole.

Then the condition that the pole shall not break is that

$$M_1 + M_2 < M$$

The calculation of $M_1$, $M_2$ and M is as follows:

Moment of Wind on Pole = $M_1$

Moment at ground level due to wind pressure on pole is:

$$M_1 = \frac{P_1 H_1^2 (D_1 + D_2)}{72}$$

$M_1$ = moment at the ground-line in ft.-lb.,
$P_1$ = wind pressure in lb. per sq.ft. of projected area of pole,
$H_1$ = height of pole in feet,
$D_1$ = diameter of pole at ground-line in inches.
$D_2$ = diameter of pole at top in inches.

The maximum bending moment due to horizontal forces at the top of the pole is ordinarily assumed to be at the ground level; it is really a little below ground level and opposite the center of pressure of the resistance furnished by the ground.

MOMENT OF WIND ON WIRES ($M_2$)

Moment at ground level due to wind pressure on wires is:

$$M_2 = \frac{P_2 H_2 n d (S_1 + S_2)}{24}$$

$M_2$ = moment at the ground in ft.-lb.
$P_2$ = wind pressure in lb. per sq.ft. of projected area of wires.
$H_2$ = height of wires above ground in feet,
n = number of wires.
d = diameter of wires in inches.
$S_1$ and $S_2$ = length of adjacent spans in feet.

Where wires are of different diameters or at different levels the formula is to be applied to each size and each level separately and the moments summed.

MOMENT OF RESISTANCE (M)

The moment of resistance or strength of a circular pole for cross-bending is:

$$M = \frac{f \pi D^3}{384} \text{ or } = \frac{f D^3}{122}.$$

M = moment of resistance of the section considered, in ft.-lb.
f = fiber stress in lb. per sq.in.
D = diameter of pole in inches.

Using the equation just given

$$M_1 + M_2 < M$$

we have computed the required circumference at ground line for the various conductor sizes, No. 6, No. 4, and No. 2 T.B.W.P.; No. 6 and No. 4, bare solid; and No. 4 and No. 2, bare stranded. We have also computed the moments tending to break the pole with these various conductor sizes. In all cases the breaking moments are found to be far less than the resisting moments of the poles. The excess resisting moment is sufficient in most cases to effect a material reduction in the amount of pull or tension at the top of the pole which has to be balanced by the guy. This will allow a reduction in the size of guy required.

Table No. 3 gives the results of these computations.

We have then assumed that the pole has deteriorated to two-thirds its initial strength, and have computed the resisting moment of the pole. We find that even under this condition the pole will, for the conductor sizes and span lengths used, have an excess of resisting moment. This excess of resisting moment will effect a reduction in the pull of the conductors to be balanced by the guy.

Table No. 4 gives the results of computations for deteriorated poles.

From these tests and other tests we have made and will continue to make, it is demonstrated that the pole acts as more than a strut; that the pole, in fact, is a part of a flexible structure, being in itself flexible and capable of safely absorbing at least part of the unbalance set up by dead-ending conductors, and there results a deviation from Rule 49.6-C of the G.O. 64A, which states:

> Where guys are used with poles or similar structures, capable of considerable deflection before failure, they shall be able to support the entire stress, the pole below the point of guy attachments acting merely as a strut. Stranded cable shall be used when the ultimate strength of the guy exceeds 1,800 lb. Anchor rods and their appurtenances shall meet the same requirements as the guy wire or strand. (See Rule 44.)

Rule 44 is the rule on Safety Factors.

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## *Guy and Conductor Tension Tests*[3]

*The purpose of these tests was to determine the factor of safety in guys on the existing lines of The Southern Sierras Power Company.*

THE locations chosen for test were selected at random, mostly in our so-called central district in the vicinity of Riverside. Almost all of the tests were made on lines of rather recent construction which were in good shape and where the guying was determined in accordance with our "Guying Chart" S-4660, sheet No. 6. Consideration was also given to the selection of locations where it would be possible to make a direct comparison between the conductor tensions and guy tensions, such as 90-deg. deadend corners.

[3] Written for pole line structures subcommittee, overhead systems committee, Engineering Section, by W. B. Loper.

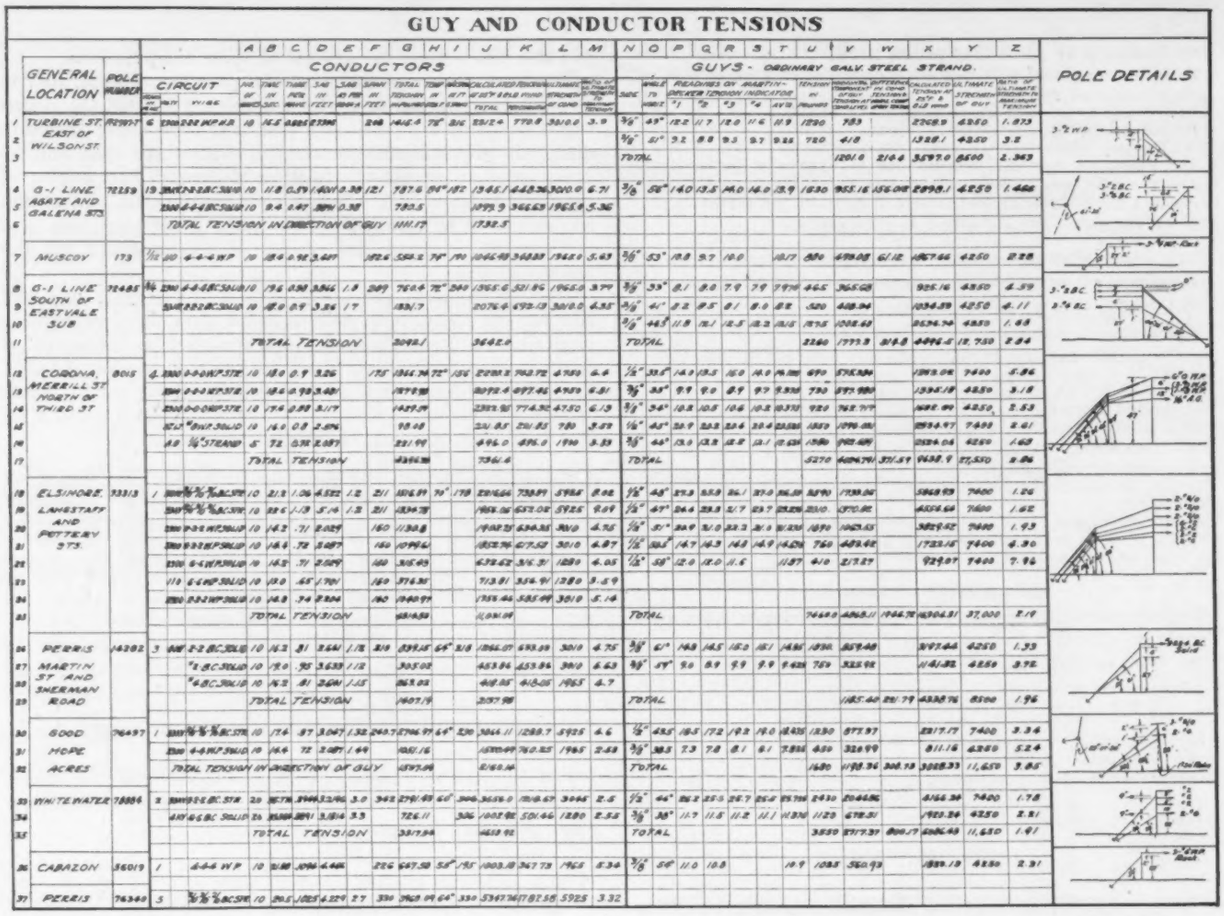
TABLE III

| Number of Conductors | Size and Type of Conductors | Minimum Pole Size and Resisting Moment | | Light Loading Moment | Average Pole Size and Resisting Moment | | Light Loading Moment | Excess Resisting Moment | Conductor Pull Balanced by Excess Resisting Moment | Maximum Pull of 3 Conductors | Conductor Pull to be Balanced |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | in. | ft.-lb. | ft.-lb. | in. | ft.-lb. | ft.-lb. | ft.-lb. | lb. | lb. | lb. |
| 3 | No. 6, TBWP | 27 | 6,504 | 5,935 | 37.7 | 17,680 | 6,373 | 11,307 | 339 | 1,110 | 771 |
| 3 | No. 4, TBWP | 27 | 6,504 | 6,270 | 37.7 | 17,680 | 6,708 | 10,972 | 329 | 1,530 | 1,201 |
| 3 | No. 2, TBWP | 28 | 7,253 | 6,986 | 37.7 | 17,680 | 7,384 | 10,296 | 309 | 2,250 | 1,941 |
| 3 | No. 4, Bare, Str. | 25 | 5,163 | 5,088 | 37.7 | 17,680 | 5,608 | 12,072 | 362 | 1,290 | 928 |
| 3 | No. 2, Bare, Str. | 26 | 5,807 | 5,650 | 37.7 | 17,680 | 6,128 | 11,552 | 347 | 1,950 | 1,603 |
| 3 | No. 6, Bare, Solid | 24 | 4,567 | 4,441 | 37.7 | 17,680 | 5,001 | 12,679 | 381 | 1,200 | 819 |
| 3 | No. 4, Bare, Solid | 25 | 5,163 | 4,845 | 37.7 | 17,680 | 6,365 | 11,315 | 340 | 1,800 | 1,460 |

TABLE IV

| Number of Conductors | Size and Type of Conductors | Deteriorated Pole Size and Resisting Moment | | Light Loading Moment | Excess Resisting Moment | Conductor Pull Balanced by Excess Resisting Moment | Maximum Pull of 3 Conductors | Conductor Pull to be Balanced by Guy |
|---|---|---|---|---|---|---|---|---|
| | | in. | ft.-lb. | ft.-lb. | ft.-lb. | lb. | lb. | lb. |
| 3 | No. 6, TBWP | 33 | 11,787 | 6,373 | 5,414 | 162 | 1,110 | 948 |
| 3 | No. 4, TBWP | 33 | 11,787 | 6,708 | 5,079 | 153 | 1,530 | 1,377 |
| 3 | No. 2, TBWP | 33 | 11,787 | 7,384 | 4,403 | 132 | 2,250 | 2,118 |
| 3 | No. 4, Bare, Str. | 33 | 11,787 | 5,608 | 6,709 | 183 | 1,290 | 1,107 |
| 3 | No. 2, Bare, Str. | 33 | 11,787 | 6,128 | 5,659 | 170 | 1,950 | 1,780 |
| 3 | No. 6, Bare, Solid | 33 | 11,787 | 5,001 | 5,786 | 204 | 1,200 | 996 |
| 3 | No. 4, Bare, Solid | 33 | 11,787 | 6,365 | 5,422 | 163 | 1,800 | 1,637 |

## GUY AND CONDUCTOR TENSIONS



### Data Obtained and Calculated

The following description refers to the attached tabulation of data. The vertical columns are lettered, A to Z, and the horizontal lines are numbered 1 to 37.

*Columns A to D—*

Measurement of sag was made by the vibration method. A chalk line was passed over the conductor and the line was moved along the conductor to a point 6 to 9 ft. from one of the supports. After the conductor had come to complete rest a vibration was set up by giving the line a quick jerk in a vertical direction. This vibration traveled along the conductor to the far support, was reflected and returned to the point where the line was over the conductor. By holding a slight tension in the line, the exact instant at which the vibration returned could be determined. A vibration was set up as above and the stop watch was started on the first or second return of the vibration. The time was taken in most cases for ten complete returns of the vibration, as shown in column B. The time required for the waves to travel from one support to the other (column C) was obtained by dividing the total elapsed time (column B) by twice the number of complete vibration returns (column A). The sag (column D) was determined by the formula:

$$\text{Sag} = 4.025t_2$$ where t = time in seconds for the vibration to travel from one support to the other.

A careful check was made of the above method for measuring sags by the use of a transit, proving it to be very reliable, as shown in Table I.

*Column E—*

Sag as per G.O. 64-A was taken from conductor sag, curve 2, page 230, G.O. 64-A. This sag, as will be noted, is the minimum sag permitted for hard drawn copper, stranded or bare, in light loading districts based on the assumption that the conductor tension should not exceed one-half its ultimate strength under conditions of 25 deg. F. , with wind exerting a pressure of 8 lb. per sq.ft. of projected area.

No sags were shown for weatherproof wire because the wire we are using is hard drawn and is not covered by G.O. 64-A sag curves.

*Column G—*

Total tension in pounds was calculated from the parabolic formula:

$$T = \frac{WL^2}{8s}$$ where T = tension in lb.
L = length of span in ft.
W = weight of conductor per ft.
S = sag in feet.

**TABLE I**

| | Length of Span | Kind of Wire | Insulator Support | Diff. in Elev. of Supports | Apparent Sag by Vibration | Apparent Sag by Transit | Diff. in Methods | Per-cent Error |
|---|---|---|---|---|---|---|---|---|
| (a) | 171.7 | No. 0 WP Str | Pin Type | 0.039 | 2.706 | 2.694 | 0.012 | 0.445 |
| (b) | 226.2 | No. 0 WP Solid | Pin Type | 0.421 | 5.461 | 5.416 | 0.045 | 0.831 |
| (c) | 240.7 | No. 2/0 BC Str | Pin Type | 3.599 | 3.047 | 3.091 | 0.044 | 1.423 |
| (d) | 338.0 | No. 2/0 BC Str | Pin Type | 40.642 | 5.645 | 5.591 | 0.054 | 0.966 |
| (e) | 628.3 | No. 2/0 BC Str | Susp. Type | 8.756 | 8.463 | 8.394 | 0.069 | 0.822 |
| | | | | | | Avg. | | 0.889 |

*Column K—*

Tension at 25 deg. F. and 8 lb. wind per conductor was calculated, using Imlay's parabolic formulas for sags and tensions under changed loading conditions. The span length used in above formulas was the average of the adjacent five spans (column I) assuming that the tension would tend to equalize itself when loading conditions were changed.

*Column M—*

"Rates of ultimate strength to maximum tension" is the ratio of the ultimate strength of the conductor as per G.O. 64-A to the tension which the conductor would have at 25 deg. F. and 8 lb. wind as shown in column K. This is the factor of safety for the conductor.

*Columns P to S—*

These are pressure gage readings on tension indicator. These readings were taken at different locations along the guy.

*Column U—*

Tension in lb. was taken from calibration charts for the tension indicator, using the average reading, column T.

*Column V—*

Horizontal component of guy tension at conductor level was calculated by moments, correcting for rake and difference in elevation of attachments of guys and conductors.

*Column W—*

Difference in conductor tension and horizontal component of guy tension is total tension, column G, minus total horizontal component, column V. (See conclusion 2.)

*Column X—*

Calculated guy tension at 25 deg. F. and 8 lb. wind was calculated, assuming that the entire conductor tension (column J) was held by the guys.

*Column Z—*

Ratio of ultimate strength of guy to maximum tension, is the ratio of the ultimate strength of the guy as per G.O. 64-A to the tension which the guy will have at 25 deg. F. and 8 lb. wind (column K). This is the factor of safety for the guy.

### General Conclusions From Data Assembled

1. *Column M*—Ratio of ultimate strength of conductor to maximum tension, or the factor of safety, ranges from 2.5 (line 33) to 9.09 (line 19) with an average of 4.79. Sixty-seven per cent of the cases worked up have a factor of safety of 4 or more.

2. *Column W*—Difference in conductor tension and horizontal component of guy tension at conductor level represents a conductor tension which is not supported by the guy. Errors which might be introduced in sag determination and

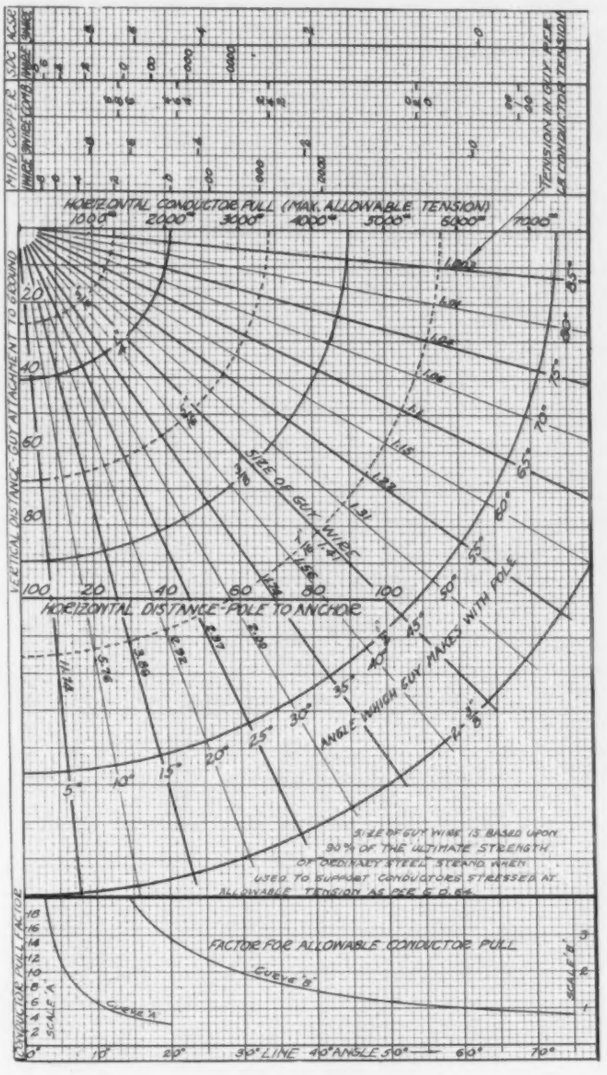

HORIZONTAL CONDUCTOR PULL (MAX. ALLOWABLE TENSION)
VERTICAL DISTANCE GUY ATTACHMENT TO GROUND
HORIZONTAL DISTANCE POLE TO ANCHOR
SIZE OF GUY WIRE
ANGLE WHICH GUY MAKES WITH POLE
FACTOR FOR ALLOWABLE CONDUCTOR PULL
35° LINE
40° ANGLE

*Fig. 1. Pole line construction chart for guy strength.*

**Instruction for Use of Guying Chart**

1. To find angle which ground guy makes with pole:
Follow horizontal line from scale "Vertical Distance Guy Attachment to Ground" to intersect vertical line from scale "Horizontal Distance Pole to Anchor." Intersection lies on radial line indicating angle.

Example: Assume height of guy attachment above ground is 30 ft.; anchor 43 ft from pole. Follow horizontal line at 30 ft. to vertical line at 43 ft.; intersection lies on radial line 55 deg.

2. To find size of horizontal span or arm guy necessary to hold given conductors at dead end:
From scales at top of chart, showing size of wires or combinations, follow vertical line downwards to scale of "Horizontal Conductor Pull." The circular arc, indicating size of guy, which lies to right of indicated point is smallest guy which may be used.

Example: Take 3 No. 2 M.H.D. bare copper conductors. Horizontal pull = 3,900 lb., next circular arc to right is ⅝ in. at 4,500 lb. which is proper size.

3. To find size of ground guy or span guy other than horizontal, necessary to hold given conductors at dead end:
Determine horizontal pull as in (2) and follow same vertical line down until it intersects vertical radial line, indicating angle of guy (see 1). The circular arc, indicating guy size lying to right or below the above point is smallest guy which can be used.

Example: Take 3 No. 2 M.H.D. B.C. Horizontal pull = 3,900 lb. Assume ground guy making vertical angle of 45 deg. with pole. Follow vertical line 3,900 lb. down to radial line 45 deg. Intersection lies outside at ⅜-in. guy arc, therefore, use next standard size ½-in. At 60 deg. angle a ⅜-in. guy would be just sufficient.

Note: Standard guy strand sizes in stock are ¼-in., ⅜-in., and ½-in. Intermediate sizes are shown as dotted arcs, but may be disregarded. Strains exceeding strength of ½-in. strand are to be held by two or more ⅜-in. or ½-in. guys as required.

4. To find size of horizontal or inclined guy at line angles where single anchorage bisecting the exterior line angle is used, line angle given: Use small chart at bottom of sheet, marked "Factor for Allowable Conductor Pull." From "Line Angle" scale follow vertical line upwards to intersect curve, thence follow horizontal line to "Conductor Pull Factor" scale at margin. If line angle is less than 15 deg. use Curve "A" with scale "A" at left, if greater than 15 deg. use Curve "B" with scale "B" at right. Divide total "Horizontal Conductor Pull in one direction by this factor. Result is the resultant horizontal conductor pull exerted by the given conductors at maximum allowable tension at the angle point. With this resultant horizontal pull proceed as in (2) or (3) to find required guy size.

Example: Take pole carrying 3 No. 8 M.H.D. B.C. wires, horizontal pull 972 lb.; and a No. 2-4-2 combination M.H.D. W.P.C. horizontal pull 3,426 lb., total H.C.P. = 4,398 lb. Line angle = 30 deg.; ground guy at 40 deg. angle to pole.

| | |
|---|---|
| Horizontal Conductor Pull of 3 No. 8's | = 972 lb. |
| Horizontal Conductor Pull of 2-4-2 comb. | = 3426 lb. |
| Total | 4398 lb. |

Follow vertical line at 30 deg. to intersect Curve "B," thence to the right read 1.93. Divide total H.C.P. 4398 lb. by 1.93 = 2275 lb. Locate 2275 lb. on "Horizontal Conductor Pull" scale at top of upper chart and follow down to intersection with 40 deg. guy angle. It falls just outside of 5/16 in. guy arc, therefore use ⅜-in. guy strand.

errors in the use of the tension indicator might account for part of this difference but it is felt by the writer that part of the tension of the conductors is supported by the pole.

The greatest difference occurred in line 25. There was evidence that the anchors had pulled slightly, which would automatically place a portion of the strain in the pole and stub.

3. *Column U*—Guy tension in pounds. It will be noted by reference to this column that where two or more guys to the same anchor or to separate anchors are used to hold a strain, the division of load between the guys is very erratic.

4. *Column Z*—Ratio of ultimate guy strength to maximum guy tension or factor of safety of guy. It will be noted that the factor of safety varies from 1.26 (line 18) to 7.96 (line 22) with an average of 2.38. Sixty-two and one-half per cent of the cases worked up have a factor of safety of 2 or more. There were three of the ten pole locations where the total guying showed less than a factor of safety of 2. These are as follows:

1. Pole No. 72,259, line 4, has a factor of safety in its guy of 1.466. This pole was set in 1912, previous to G.O. 64 and was not guyed in accordance with our guy chart.

2. Pole No. 14,282, line 29, has a factor of safety in its guys of 1.96. If the guys had been properly located with respect to the conductor level, the factor of safety would have been about 2.

3. Pole No. 78,884, line 35, has a factor of safety in its guys of 1.91. It was felt, previous to any actual checks made on the line, that this line was pulled up too tight and a work order had been prepared to cut slack into this line.

It would therefore seem that, under the existing stringing tensions, our guying specifications as set up on our guy chart S-4660 are adequate to comply with the required factor of safety of 2.

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## *Rate of Deterioration of Untreated Poles*[3]

*The following tabulated data, prepared by Ralph E. Hill, is compiled from reports of inspections made during the years of* 1926, 1927 *and* 1928. *The report covers several different districts and does not take into account termite damage except in the San Francisco and Sacramento areas. It will be noted that the rate of deterioration varies greatly in the several areas shown, which variation we assume to be due to both the character of soil and climatic conditions, as more than* 10,000 *poles are reported on in both coast and interior areas.*

[3] Written for pole line structures subcommittee, by R. E. Hill.

STATISTICS OF INSPECTION OF JOINT POLES

**SACRAMENTO AND NORTH SACRAMENTO**
**Tested 1927 and 1928**

| Year Set | Number Tested | Found Stubbed | Deteriorated | Stubbed and Deteriorated | Percentage of Deterioration |
|---|---|---|---|---|---|
| 1919 | 67 | .. | 4 | 4 | 5.97 |
| 1918 | 64 | .. | 4 | 4 | 6.25 |
| 1917 | 103 | 1 | 13 | 14 | 13.59 |
| 1916 | 118 | 1 | 11 | 12 | 10.17 |
| 1915 | 131 | 4 | 18 | 22 | 16.80 |
| 1914 | 131 | 3 | 9 | 12 | 9.16 |
| 1913 | 115 | 6 | 18 | 24 | 20.87 |
| 1912 | 589 | 11 | 101 | 112 | 19.02 |
| 1911 | 75 | 2 | 9 | 11 | 14.67 |
| 1910 | 34 | .. | 10 | 10 | 29.41 |
| 1909 | 48 | 1 | 8 | 9 | 18.75 |
| 1908 | 23 | .. | .. | .. | ..... |
| 1907 | 2 | .. | .. | .. | ..... |
| 1906 | 1 | .. | .. | .. | ..... |
| 1904 | 1 | 1 | .. | .. | ..... |
| | 1,502 | 30 | 205 | 235 | 15.65 |

Average deterioration, 15.65%.
Total number of poles showing termite infestation, 496, or 33%.
All poles untreated.

STATISTICS OF INSPECTION OF JOINT POLES

**BERKELEY**
**Tested 1926**

| Year Set | Number Tested | Found Stubbed | Deteriorated | Stubbed and Deteriorated | Percentage of Deterioration |
|---|---|---|---|---|---|
| 1918 | 33 | ... | 1 | 1 | 3.03 |
| 1917 | 112 | 5 | 8 | 13 | 11.6 |
| 1916 | 117 | 3 | 2 | 5 | 4.3 |
| 1915 | 71 | 2 | 12 | 14 | 19.7 |
| 1914 | 90 | 11 | 4 | 15 | 16.7 |
| 1913 | 99 | 10 | 8 | 18 | 18.2 |
| 1912 | 90 | 12 | 4 | 16 | 17.8 |
| 1911 | 40 | 4 | 8 | 12 | 30.0 |
| 1910 | 29 | 2 | 7 | 9 | 31.2 |
| 1909 | 34 | 7 | 5 | 12 | 35.1 |
| 1908 | 27 | 4 | 5 | 9 | 33.3 |
| 1907 | 15 | 4 | 4 | 8 | 53.3 |
| 1906 | 5 | ... | 2 | 2 | 40.0 |
| 1902 | 1 | ... | ... | ... | ..... |
| | 763 | 64 | 70 | 134 | 17.56 |

Average Deterioration, 17.56%. All poles untreated.

**OAKLAND - PIEDMONT - EMERYVILLE**
**Tested 1927**

| Year Set | Number Tested | Found Stubbed | Deteriorated | Stubbed and Deteriorated | Percentage of Deterioration |
|---|---|---|---|---|---|
| 1919 | 325 | 7 | 16 | 23 | 7.08 |
| 1918 | 207 | 5 | 11 | 16 | 7.75 |
| 1917 | 350 | 8 | 21 | 29 | 8.28 |
| 1916 | 556 | 24 | 36 | 60 | 10.79 |
| 1915 | 410 | 34 | 47 | 81 | 19.76 |
| 1914 | 484 | 32 | 50 | 82 | 16.95 |
| 1913 | 264 | 32 | 43 | 75 | 28.40 |
| 1912 | 393 | 33 | 34 | 67 | 17.05 |
| 1911 | 281 | 46 | 27 | 73 | 25.98 |
| 1910 | 142 | 31 | 23 | 54 | 38.02 |
| 1909 | 125 | 10 | 25 | 35 | 28.00 |
| 1908 | 56 | 7 | 15 | 22 | 39.28 |
| 1907 | 123 | 9 | 21 | 30 | 24.40 |
| 1906 | 30 | 4 | 3 | 7 | 23.30 |
| 1905 | 8 | 2 | 2 | 4 | 50.00 |
| 1904 | 22 | 2 | 3 | 5 | 22.74 |
| 1903 | 1 | 1 | ... | 1 | 100.00 |
| 1896 | 1 | ... | ... | ... | ..... |
| | 3,778 | 287 | 377 | 664 | 17.58 |

Average deterioration, 17.58%. All poles untreated.

**RICHMOND - HAYWARD - SAN LEANDRO - ALBANY - EL CERRITO**
**Tested 1927**

| Year Set | Number Tested | Found Stubbed | Deteriorated | Stubbed and Deteriorated | Percentage of Deterioration |
|---|---|---|---|---|---|
| 1919 | 179 | 4 | 4 | 8 | 4.47 |
| 1918 | 63 | 7 | 5 | 12 | 19.06 |
| 1917 | 108 | 7 | 11 | 18 | 16.67 |
| 1916 | 165 | 16 | 12 | 28 | 16.97 |
| 1915 | 85 | 17 | 7 | 24 | 28.23 |
| 1914 | 68 | 9 | 5 | 14 | 20.59 |
| 1913 | 115 | 29 | 19 | 48 | 41.75 |
| 1912 | 150 | 22 | 11 | 33 | 22.00 |
| 1911 | 22 | 7 | 1 | 8 | 36.36 |
| 1910 | 5 | 3 | .. | 3 | 60.00 |
| 1909 | 1 | .. | .. | .. | ..... |
| 1908 | 1 | 1 | .. | 1 | 100.00 |
| 1906 | 44 | .. | 4 | 4 | 9.09 |
| 1905 | 6 | .. | .. | .. | ..... |
| | 1,012 | 122 | 79 | 201 | 19.86 |

Average deterioration 19.86%. All poles untreated.

**SAN FRANCISCO**
**Tested 1927**

| Year Set | Number Tested | Found Stubbed | Deteriorated | Stubbed and Deteriorated | Percentage of Deterioration |
|---|---|---|---|---|---|
| 1919 | 237 | .. | 16 | 16 | 6.8 |
| 1918 | 283 | .. | 25 | 25 | 8.8 |
| 1917 | 675 | .. | 39 | 39 | 5.8 |
| 1916 | 835 | 4 | 76 | 80 | 9.6 |
| 1915 | 297 | 2 | 57 | 59 | 19.9 |
| 1914 | 195 | 11 | 19 | 30 | 30.0 |
| 1913 | 120 | .. | 16 | 16 | 13.3 |
| 1912 | 114 | .. | 22 | 22 | 19.3 |
| 1911 | 68 | .. | 13 | 13 | 19.1 |
| 1910 | 88 | 1 | 21 | 22 | 25.0 |
| 1909 | 125 | 1 | 25 | 26 | 20.8 |
| 1908 | 97 | 3 | 23 | 26 | 26.8 |
| 1907 | 129 | 2 | 17 | 19 | 14.7 |
| 1906 | 12 | .. | 5 | 5 | 41.7 |
| 1905 | 15 | .. | 1 | 1 | 6.7 |
| 1904 | 3 | .. | 1 | 1 | 33.3 |
| 1903 | 32 | 2 | 3 | 5 | 15.6 |
| 1902 | 1 | .. | .. | .. | ..... |
| | 3,326 | 26 | 379 | 405 | 12.15 |

Note:—Total number of poles showing termite infestation 1,069 or 32%.
Average deterioration,12.15%. All poles untreateed.

## *Methods of Insulating Guy Wires From Bond Wires*[3]

*This subject was suggested to determine the best method of insulating guy wires from bond wires. In endeavoring to determine this we find that all of the companies in this section use different methods, all of which are similar. The committee also finds that the methods used by the individual companies are apparently satisfactory to the companies using them. From the information at hand the committee is unable to determine which method is the best. Further study and possible standardization might solve the problem.*

FROM the information gathered from the various companies in this section we find the following methods used:

### Four Methods Used by One Company

View 1, Fig. 1, shows a ⅜ x 8-in. fiber tube under the 3-in. redwood molding and over the guy where it is wrapped around the pole.

View 2, Fig. 1, acomplishes the same purpose with a flat fiber ⅜-in. thick by 3-in. wide by 8-in. long. Both of these methods have been approved by the Railroad Commission and have been used in much of this company's construction. Inasmuch as the fiber insulation in these two methods is concealed by the redwood molding, a white stripe has been painted around the molding at top and bottom of the fiber to indicate where it has been used. This is at the suggestion of the commission engineers.

[3] Written for pole line structures subcommittee by N. P. Carlsen.

View 3, Fig. 1, represents a case in which the guy collar and guy wire are installed over the redwood molding, depending entirely on the molding for insulation. This latter method has proved very satisfactory where it has been convenient to make the installation in this way. There have been some failures, however, from methods No. 1 and No. 2, particularly from No. 2, due to leakage and subsequent burning of the fiber when it has become wet during rainstorms.

Method No. 4, as shown on the print, was devised to replace methods No. 1 and No. 2 and was brought about due to the adoption of hardwood molding after its approval by the Railroad Commission. This consists of a ¾-in. x 1½-in. x 8-in. hardwood block, notched in the center to span the guy wire where wrapped around the pole, with the hardwood molding butting against each end of the block and a short piece of molding over the top to cover the wire where it lies on the outside of the block. This seems to make a very good installation and has been used with the hardwood molding. The block is of the same material as the molding and has an equal or greater thickness of wood than the greatest thickness of wood at any point in the hardwood molding.

### Other Methods in Use

Another company states that it uses a strip of fiber ⅛ in. thick, 1 in. wide and 18 in. long, which is placed under the ground wire and over the guy wire and pole collar, insulating the ground wire from the guy and pole collar. A piece

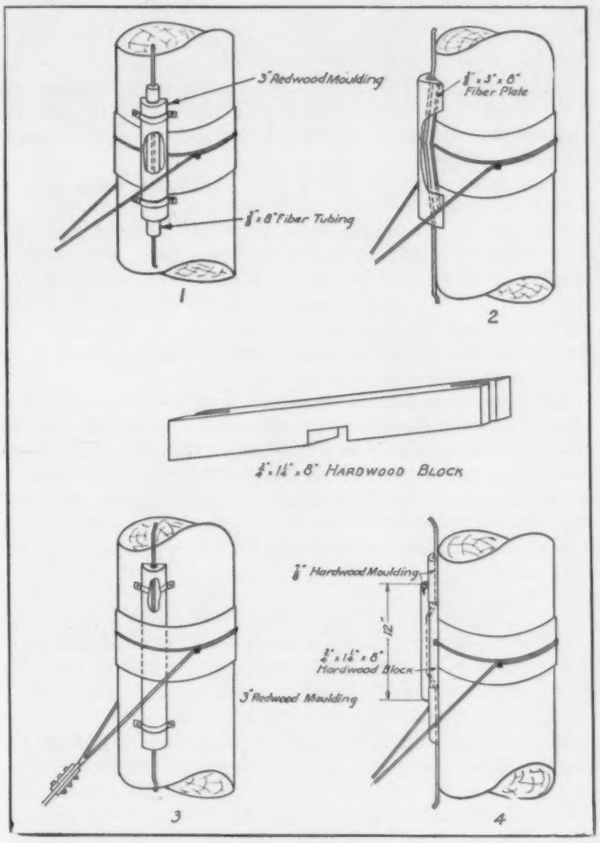


*Fig. 1. Four methods used by one company for the insulating of guy wires from bond wires.*

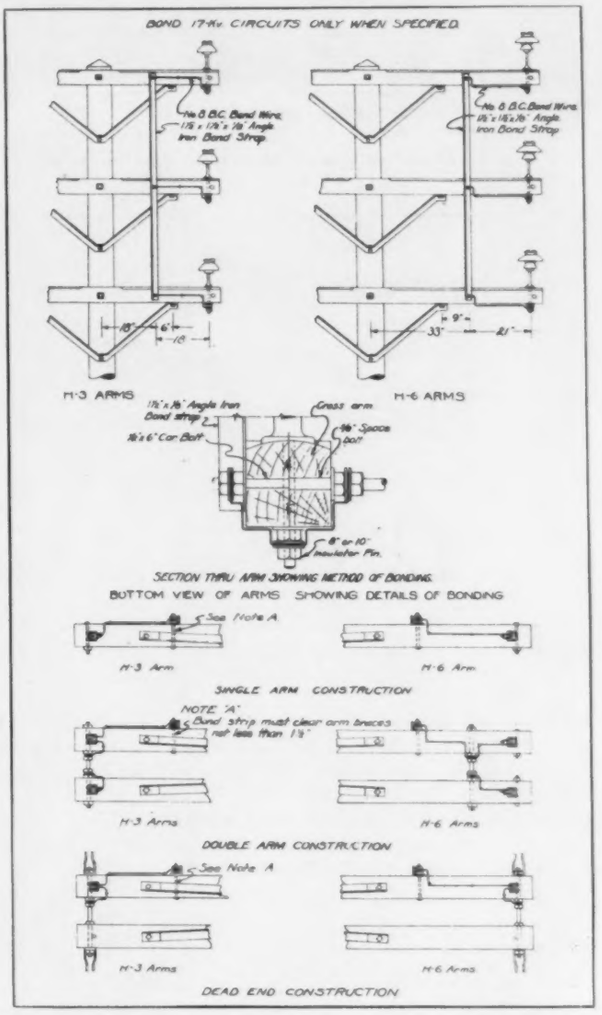


*Fig. 2. Bonding where no high tension circuits are carried on wood poles.*

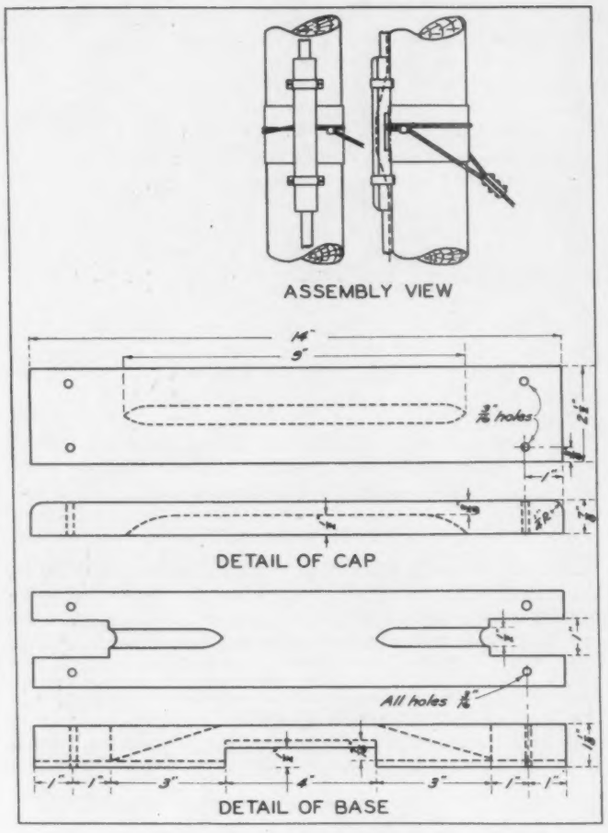


*Fig. 3. Insulating ground wires from guys on poles.*

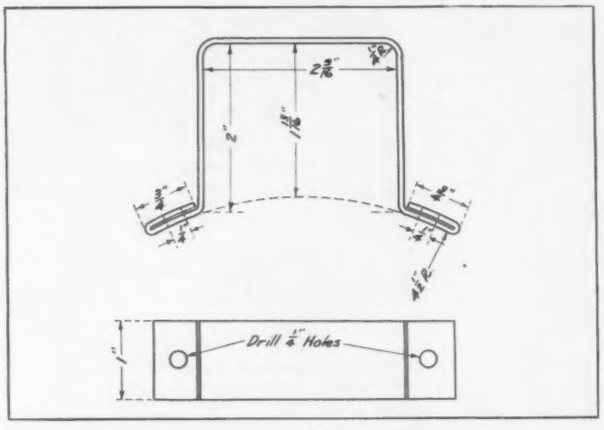


*Fig. 4. Ground wire insulating bridge strap. Material is 1 in. No. 18 gage galvanized hoop iron, 9½ in. long.*

of hardwood ground wire cover is then placed over the ground wire and fastened at each side with copper weld staples, or 1-in. pipe straps. By using this small hardwood molding, it is found to bend enough to make a very satisfactory job of covering the ground wire.

Another company states that it uses ground molding between the guy wire and the bond wire.

The fourth company replies as follows:

In case of vertical dead-ends, we deliberately contact the bond wire with the guy wire and under G.O. 64-A do not install an insulator in the guy. Therefore the bond wire becomes a grounded bond. We would consider it hazardous to introduce any insulation between the bond wire and guy wire under the conditions, since any practical insulation would not be sufficient to withstand the high-tension voltage to ground in case of insulator failure and the result would be a flash-over between the bond and guy, probably resulting in a pole fire.

In case of two high-tension circuits on wood poles, our practice is to use three arms with conductors of each circuit in vertical configuration. Bonding for this type of construction is shown in Fig. 2. We might say that we formerly brought the bond wires to the poles, thence down the pole, covered with wood molding, but we find our present method of attaching a piece of light angle iron from crossarm to crossarm a much more satisfactory method. This at once, to a large extent, removes the fire hazard which exists in case of insulator failure causing arcing between the bonds on opposite sides of the pole. It also eliminates the problem of contacting or insulating from guy wires attached to the pole.

Another problem directly related to the question of insulating bond wires from guy wires is that of insulating ground wires from poles. Where we wish to carry a ground wire over an existing guy wire we use a hardwood ground-wire insulating bridge attached by means of straps and galvanized nails as shown in Figs. 3 and 4. Where it is desired to place a guy around a pole on which there is an existing ground wire, we use a molding guy plate, N.E.L.A. standard D299-28T. This is carried as a standard article by a number of the manufacturers of pole line hardware.

There is another method of insulating guy wires from ground wires which, while we have not used it, would seem entirely feasible —that is by attaching the guy wire to either an eye-bolt or thimble eye-bolt through the pole.

---

## *Steel Versus Wood Poles For Distribution*[3]

*The use of steel poles has been increasing rather rapidly in the last few years and due to the number of different designs on the market the subcommittee thought it would be of interest to the utilities in the state to see what has been done by the various companies in their use. This report contains several representative installations, curves showing the relation of costs of the various poles and advantages and disadvantages in the use of the various types.*

IN RECENT years one of the greatest problems in the distribution of electrical energy has been the selection of a suitable material for poles. In dealing with this problem poles must be used which have the necessary strength requirements, ability to withstand the elements and the attack of termites.

Wood poles have been generally used but a study over a period of years indicates that the life of wood poles is rather low, due to natural rot and the damages resulting from termites. Butt-treated poles have been used with a great deal of success, but termites have been found in several instances in the untreated section. The next step was the use of full treated poles which has overcome this difficulty, but due to the increase in weight and cost they have not been entirely satisfactory.

Everyone is more or less familiar with the various species of wood poles in distribution work but the use of the various designs of steel poles is relatively new. There have not been many steel poles used on the Pacific Coast for this type of work, but due to the increasing use of these poles, the subcommittee thought it would be of interest to show a few typical installations which bring out the possible uses of steel poles.

### Typical Installations in River Crossings

Tubular and lattice steel poles have been used for river crossing masts in several instances. One company has submitted a picture of an installation of a tubular steel mast as shown in Fig. 1.

This mast is 150 ft. in height and was installed in six 25-ft. sections and guyed at every other joint. This results in a very trim installation and is particularly advantageous over a wood mast where the structure is subjected to fire.

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[3] Written for pole line structures subcommittee by Carlton L. Yager.

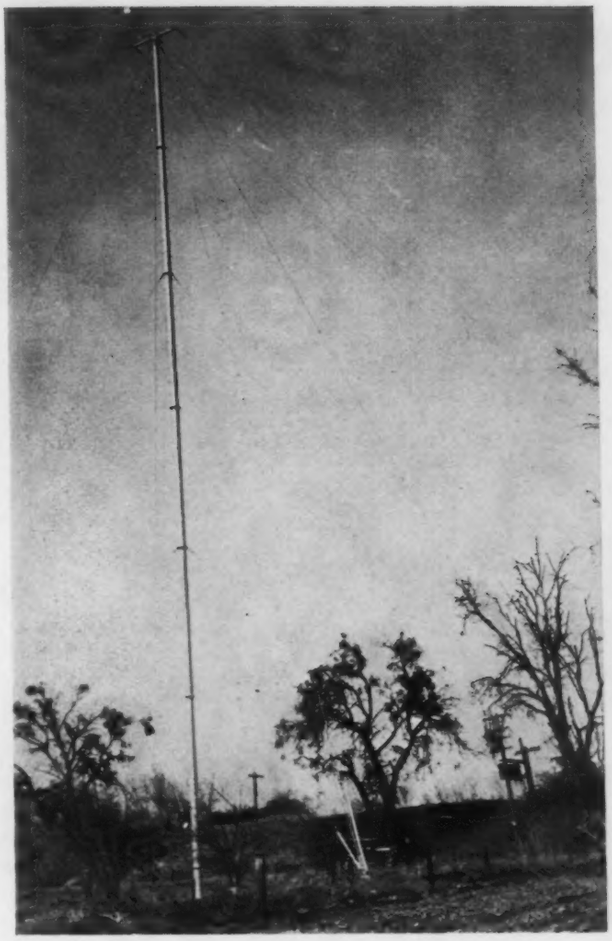

*Fig. 1. 150-ft. tubular steel river crossing mast.*

*Fig. 2. 155-ft. lattice steel river crossing mast.*

Fig. 2 shows a lattice steel pole, 155 ft. in height, used for a river crossing, which is typical of several crossings installed by one company. This is also a very neat installation and the company has used a number of such installations very successfully.

### Riser Poles

Tubular steel poles have been found to be particularly adapted for the installation of risers in connecting underground and overhead systems and in bringing circuits out of substations. The success in the use of these poles lies in the fact that the circuits are run up through the center of the pole in small pipes installed for the purpose and brought out at the desired level. This gives a much better appearance than the usual wood pole installation where the riser pipes are installed on the face of the pole and usually covered with a bulky, unsightly boxing. The companies which have used such installations state that they have given perfect satisfaction and that they are far superior to any other types which have been used. Pole top fires, resulting from the breaking down of insulators or pot heads, are entirely eliminated by the use of this type of installation.

Figure 3 shows a 65-ft. tubular steel pole having a base diameter of 26 in. and an 18-in. top. The vacant top arm is to be used for a future 33-kv. circuit while the next arm carries two 12-kv. circuits. The third arm supports three street light circuits and the fourth one a 4-kv. distribution primary circuit.

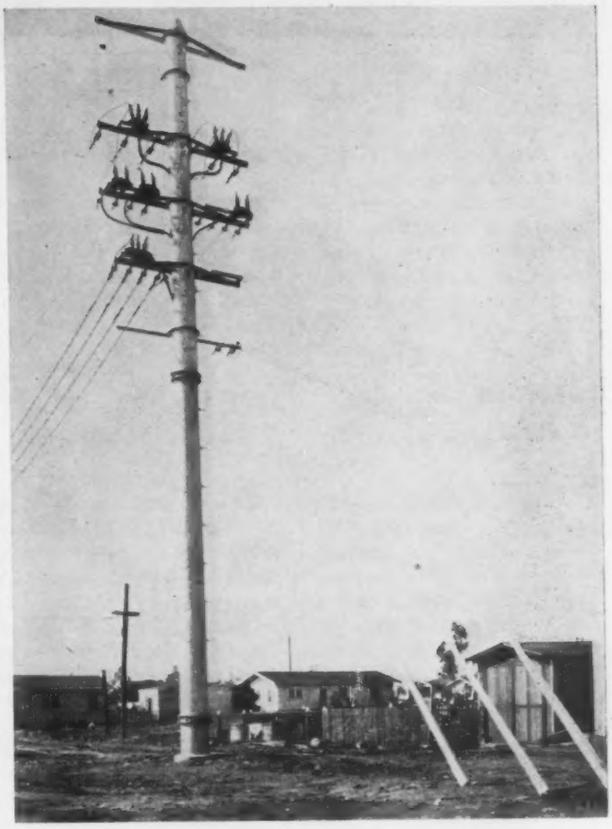

*Fig. 3. 65-ft. tubular steel riser pole.*

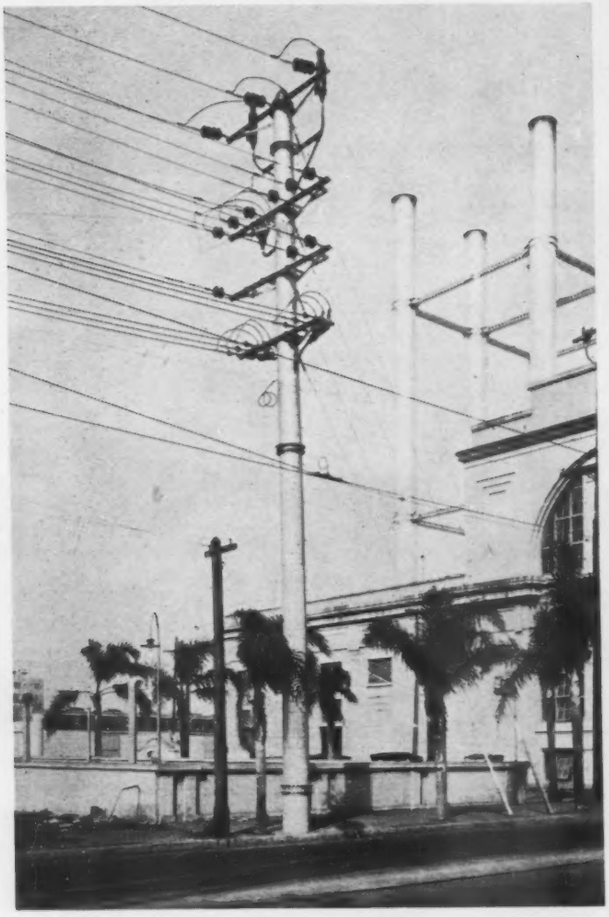

*Fig. 4. Tubular steel riser pole of the same type as Fig. 3.*

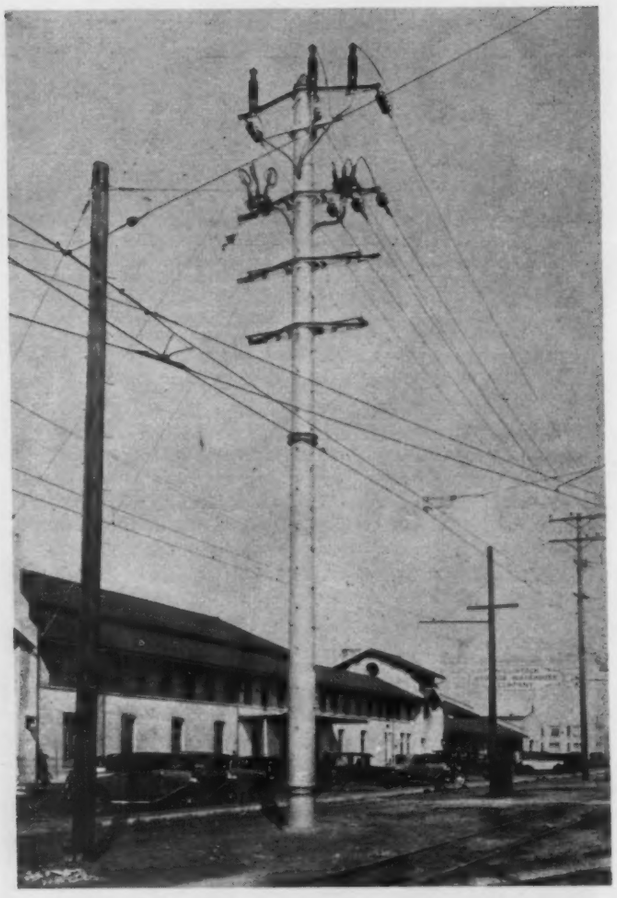

*Fig. 5. Tubular steel riser pole of the same type as Fig. 4.*

Fig. 4 covers another 65-ft. riser pole of the same type as Fig. 3, carrying one 33-kv. circuit, three 12-kv. circuits and two 2.3-kv. circuits.

Still another riser pole 65 ft. in height is shown in Fig. 5. This supports a 33-kv. circuit, a 12-kv. circuit and has a position for future circuits. You will note in this picture the different types of potheads used for the different voltage circuits and the methods of installation.

The two tubular steel riser poles shown in Fig. 6 support several 4-kv. circuits and replaced three wood riser poles which were necessary to accomplish the same results. The pole in Fig. 7 shows a close up view of the pole on the left in Fig. 6.

### Combination Poles

One company reports that it has used a lattice steel pole line as a combination distribution line and tie line installation and that this line has been very successful. The poles used are 66-ft. lattice steel poles with a 10-in. square top and a 24-in. square base, set in concrete 36 in. x 36 in. x 8 ft. deep. This line, which is shown in Fig. 8, was installed in 1912 and carries three 33-kv. circuits, a 2.3-kv. single-phase circuit, secondary and telephone circuits. Due to the fact that this line carries a distribution circuit and services, the spans used were relatively short for steel poles. As a rule when steel poles carry only tie lines or transmission lines, spans of greater lengths can be used due to the added strength of steel over wood poles.

A number of cities have recently been attempting to force the pole using companies to reduce the pole duplication to a

*Fig. 6. Two tubular steel riser poles used to support several 4-kv. risers.*

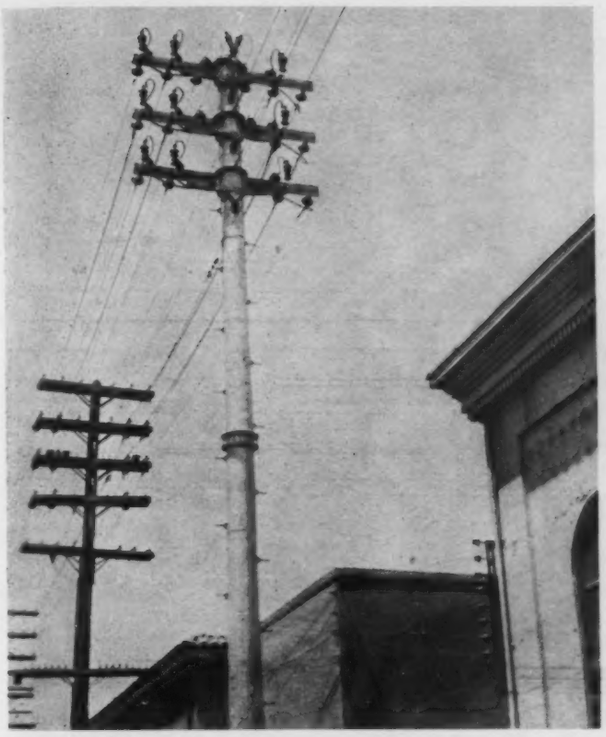

*Fig. 7. Close up of tubular riser pole on left of Fig. 6.*

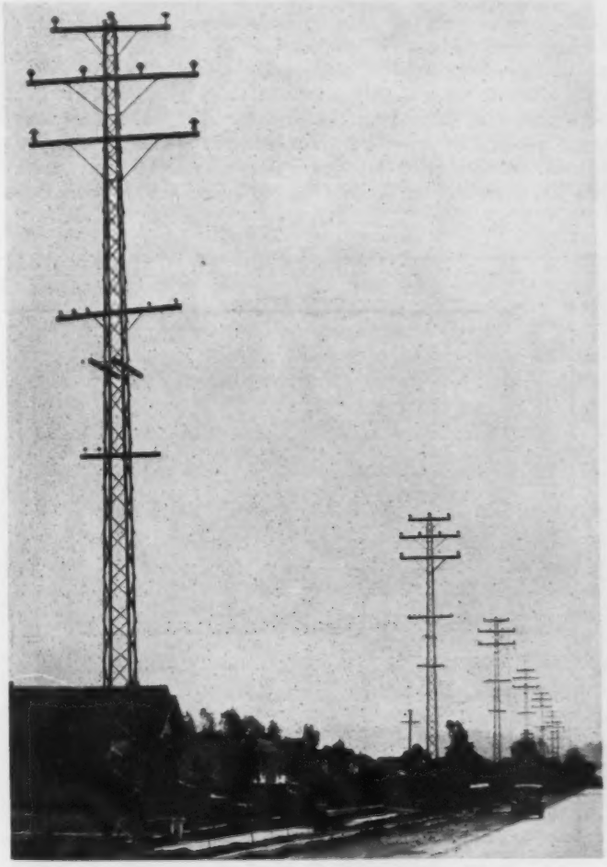

*Fig. 8. Lattice steel pole line carrying three 33-kv. circuits, a single phase, 2.3-kv. circuit and secondary.*

*Fig. 9. Combination fluted tubular steel pole used for street lighting and trolley span to eliminate duplication.*

minimum. In line with this problem it has been necessary to select a pole which can be used to carry distribution circuits, street lighting units and circuits and trolley span wires.

Several such installations have utilized fluted combination poles as shown in Fig. 9. As may be noted, these poles support two ornamental street lighting units, two small street lighting transformers and the trolley span wire. The line on the right side of this street also carries a railway feeder circuit. The electric distribution circuits are not carried on this line as it was found that the electric service could be supplied from side streets.

A recent installation of fluted combination poles is shown in Figs. 10 and 11. This line of poles supports distribution lines, street light standards or units and trolley spans. Before this installation was made, three separate sets of poles were required to carry the circuits and equipment which are

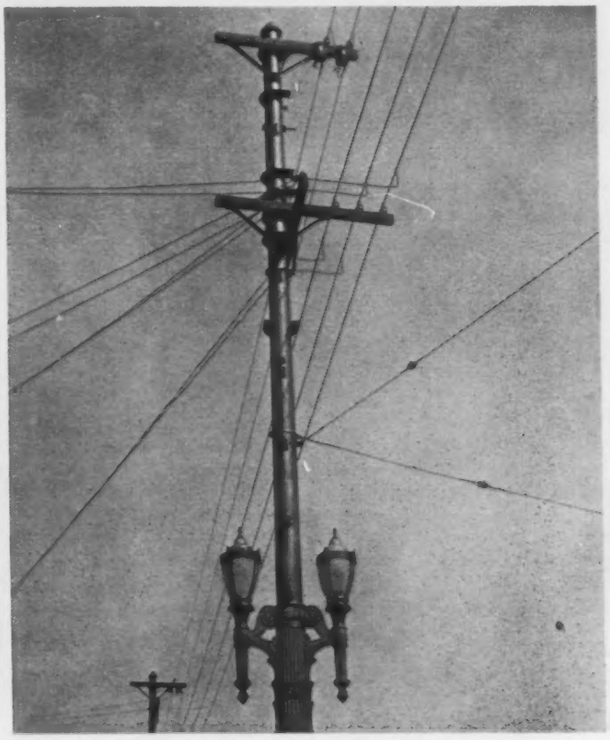

*Fig. 10. Combination fluted tubular steel pole used for street lighting, distribution and trolley span.*

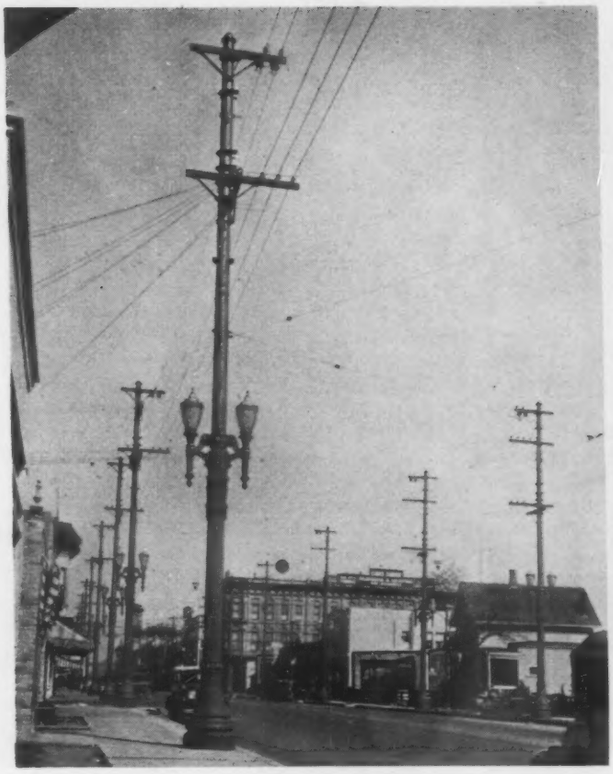

*Fig. 11. View of street where standards shown in Fig. 10 were used to eliminate duplication.*

now supported by one combination pole. This resulted in the elimination of a very objectionable pole duplication as shown in Figs. 12 and 13.

*Fig. 12. Pole duplication on street shown in Figs. 11 and 13 before installation of fluted steel poles.*

*Fig. 13. Same as Fig. 12 after installation of fluted steel poles.*

## Comparison of Costs

The cost of steel poles, as we would expect, is considerably higher than the cost of the various species of wood poles which have been used in distribution work.

In order to show a comparison of these costs, a chart has been prepared indicating the cost installed of the various types used. The prices of the poles are based on a delivery of approximately 10,000 poles per year. To that price has been added the cost of installation. The manufac-

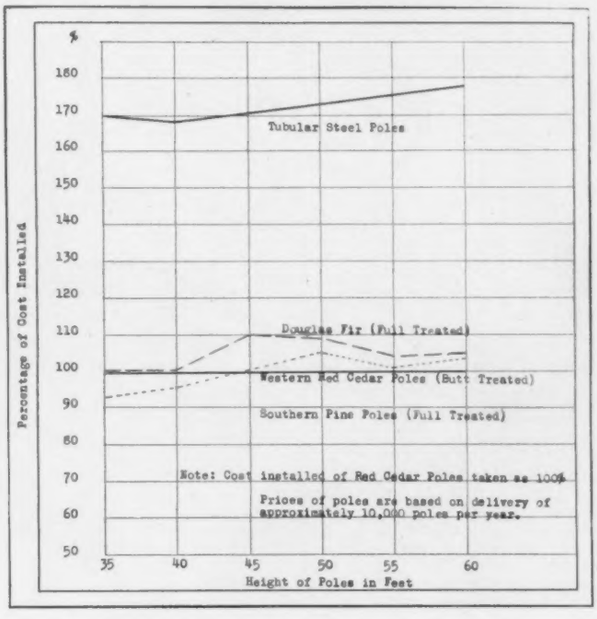


*Fig. 14. Curves showing comparison of costs of several types of wood poles and tubular steel poles.*

turers of steel poles suggest that their poles be set in concrete to obtain best results but the prices used to plot the curve were not based on concrete foundations so as to give a fair comparison with wood poles.

As every one is more or less familiar with western red cedar poles, that type has been used as a base of 100 per cent and the cost installed of the other poles expressed as a percentage of that cost. This indicates that the various wood poles fall within the 90 per cent to 110 per cent band, while the tubular steel poles used are rather close to the 170 per cent point. This indicates that steel poles are about 70 per cent higher than wood poles.

It has been found that the life of steel poles is considerably longer than wood poles and in many instances they are very much more satisfactory, due to their being of a more permanent nature. This is not always the case however, as we find that the mortality rate of distribution poles is very low and in many cases as low as ten years, due to underground agitation and public sentiment in general. For this reason the companies have been confronted with the problem of determining whether or not structures of a more permanent nature than wood poles are warranted, since the useful life of distribution poles is so low.

### Advantages

Steel poles have a number of advantages over wood poles. They have a longer life, greater strength and maintenance costs are considerably less than for wood poles. Due to the reduced size of the butts of steel poles, they are particularly adapted for use where the sidewalks are narrow and where appearance is a major consideration. Where poles are subjected to fire hazards from brush or forest fires, they are also suitable and pole top fires are entirely eliminated by their use.

### Disadvantages

The cost of steel poles is considerably higher than wood poles, especially where short spans must be used, as in distribution work. Where it is necessary to work on live lines, steel poles have not been generallly favored, as a considerable hazard is introduced on account of the workmen being in contact with the grounded pole. As stated before, it is a question whether or not structures of such a permanent nature are justified, on account of the low mortality of distribution poles.

From the foregoing it will be noted that there is a definite field in which steel poles have a very prominent place, and for such uses they are without doubt far superior to wood poles. It seems that there is a need for a lighter steel pole than has been in general use and one that could be produced in large quantities at a considerable reduction in price.

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## *Protective Devices**

*This report notes the progress and general trend in the design of protective devices and gives the present tentative recommendations for rating fuse links with a resume of the practices of the utilities of the Pacific Coast Electrical Association in regard to the application of protective devices to their distribution lines.*

*Inclosed cutouts are used on lines of 5,000 volts and less, and the open type on the higher voltage lines.*

*Expulsion type cutouts rated at 60 amp. should not be used for normal currents in excess of 50 amperes or where the short circuit current may exceed 1,000 amperes. Cutouts rated at 150 amperes should not be used for normal currents in excess of 100 amperes or where the short circuit current may exceed 2,000 amperes. Liquid or oil immersed fuses should be used for normal currents in excess of 100 amperes or where the short circuit current may exceed 2,000 amperes.*

*Cutouts with a comparatively high voltage rating or a large creepage surface should be used in areas subject to sea fog.*

THE capacity of our distribution systems is increasing daily and this causes the problem of safety and continuity of service to become increasingly more complex. Regardless of how well a distribution system be designed, troubles will occur. It is therefore necessary that adequate protective equipment be used in order that the troubles may be minimized and as small a section as possible of the system affected. That the manufacturers are aware of the increasing reliability and ruggedness required of protective equipment is shown by the improvements and new designs announced almost monthly by them.

### Fuse Link Standardization

The subcommittee on switching and protective devices of the material and equipment group, overhead systems committee, National Electric Light Association, has been working for some time on the standardization of fuse links for box type cutouts for use on distribution circuits. A rating for fuse links tentatively adopted by them is as follows:

> Fuses shall carry their rated capacity indefinitely without causing visible deterioration of the cartridge and shall blow at 125 per cent of rated capacity plus 10 per cent in five minutes in any fuse box.

The National Electrical Manufacturers Association which is also studying the standardization of protective equipment has suggested the following rating:

> Fuse cutouts shall be rated in r.m.s. amperes and their fuse links shall carry their rated current for one hour, starting cold without causing visible deterioration of the fuse link or adjacent parts. Fuse links shall not be operated continuously at over 65 per cent of their rated current. They shall blow at 150 per cent of their rated current in less than 5 minutes with an ambient temperature of 20 to 30 deg. C. on all other fuse parts including class A and B insulating material adjacent to or in contact with the fuse tube.

We think the logical rating for a fuse link should be its continuous carrying capacity, for this method of rating is consistent with the method of rating other electrical apparatus.

The National Electrical Manufacturers Association has adopted a list of standard fuse sizes and has indicated a preferred group of sizes from this standard as shown in Table I.

### Some New Developments

Most of the manufacturers are now making a so-called "Standardized Fuse Link" that may be used in the link holders of the various manufacturers in cutouts rated at 7,500 volts and less. This fuse link is made long enough to fit the longest link holder and is cut off with a pair of pliers when used in shorter link holders.

An interchangeable link holder is badly needed but none is available at the present time. The National Electrical Manufacturers Association is working on this problem but its successful solution looks doubtful.

One manufacturer has developed a new fuse link with a time leg only slightly greater than the time leg of the relay settings of station breakers. This fuse link will blow in less than 5 minutes on 150 per cent of rated load and in 1/10 second with a current ten times the rating. Time current characteristic curves of various manufacturers' 30-amp. fuse

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* Report of subcommittee on protective devices, overhead systems committee, Engineering Section. C. B. Judson, chairman. C. R. Benson, O. R. Evans, F. J. Gleiss, J. R. Jensen, Homer Keesling, C. S. King, E. A. McGinty, H. H. Minor, E. S. Moreland, E. R. Northmore, C. C. Potts, G. M. Richardson, H. J. Schomberg, Ray Sheppard, A. L. Williams, C. E. Young.

TABLE I

STANDARD SIZES OF FUSE LINKS AS ADOPTED BY N.E.M.A.

| FUSE LINKS FOR 60 AMP. CUTOUTS | FUSE LINKS FOR 150 AMP. CUTOUTS |
|---|---|
| 1* | 1* |
| 2 | 2 |
| 3* | 3* |
| 5* | 5* |
| 7 | 7 |
| 10* | 10* |
| 15* | 15* |
| 20 | 20 |
| 25 | 25 |
| 30* | 30* |
| 40 | 40 |
| 50 | 50 |
| 60* | 60* |
| | 75 |
| | 80 |
| | 100* |
| | 125 |
| | 150* |

PREFERRED SIZES MARKED WITH AN ASTERISK

links have been plotted, from data submitted by the manufacturers, on one graph for comparison purposes, as shown in Fig. 1.

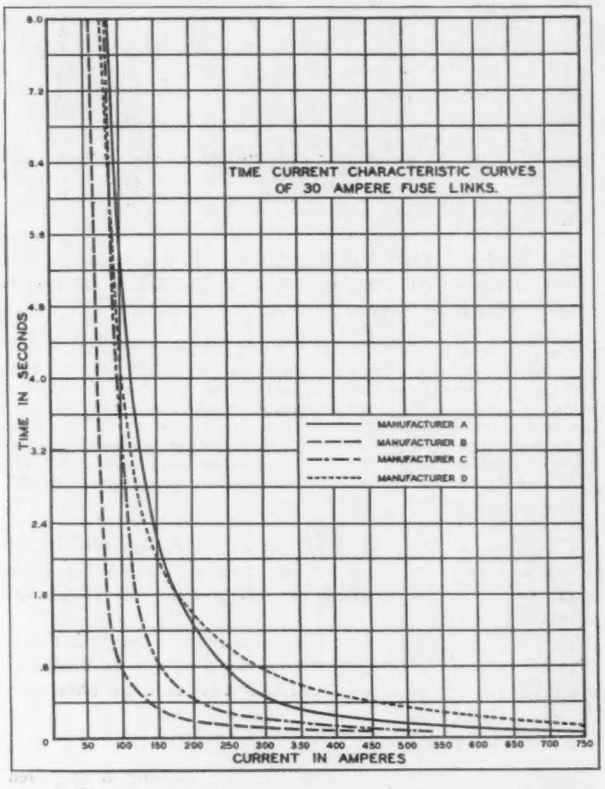


*Fig. 1. Time current characteristic curves of 30-ampere fuse links.*

A new open type 7,500 to 15,000-volt cutout has been designed with a new fuse holder tube which it is claimed will withstand exposure to the weather much better than previous types. The specially treated and reinforced fiber tube is covered with a porcelain tube between the contacts as an additional protection against the weather. Past experience with all glass or porcelain tubes has not been favorable, due to their lack of mechanical strength resulting in considerable breakage. The performance of this modified tube will be watched with considerable interest.

A new low voltage thermal cutout of interest is just being introduced by one manufacturer. It is installed in the secondaries so that the current heats a resistor in a definite ratio to the load carried by the transformer. When the load reaches a given value the resistor melts a slug, with a low melting temperature, releasing a set of springs which open the circuit.

### Current Carrying Capacity of Cutouts

Tests made on the current carrying capacity of 4-kv. line cutouts with the same rating was found very inconsistent for various manufacturers. In all cases, when the fuse was carrying the rated cutout load, the fuse would get very hot and the 50 and 60-amp. rated fuse tubes carbonized. The committee recommends that cutouts rated at 60 amperes should not be used for currents in excess of 50 amperes and cutouts rated at 150 amperes should not be used for currents in excess of 100 amperes. These tests indicate that the weakest part of the cutout is the fuse tube. A fuse link made of material with a low melting point is desirable but due to its low conductivity, materials with higher melting points are necessary. The tendency for the fuse tube to char is readily apparent from a comparison of the following temperatures:

| | |
|---|---|
| Melting point of fuse link | 419 deg. C. |
| Boiling point of fuse link | 840 deg. C. |
| Charring point of fiber | 185 deg. C. |

In order to keep the temperature of the fuse link below the charring temperature of the fiber, it is recommended that the fuse link should not normally carry over 65 per cent of its rating. This is the general practice of the member companies as they all over-fuse nearly 100 per cent.

### Interrupting Ability of Cutouts

On tests made with currents from 120 per cent to 150 per cent of the fuse rating, the cutouts functioned satisfactorily. In some instances the tube was charred.

On short circuit tests of over 1,000 amperes on the 60-amp. rated cutouts, and of over 2,000 amperes on the 150-amp.

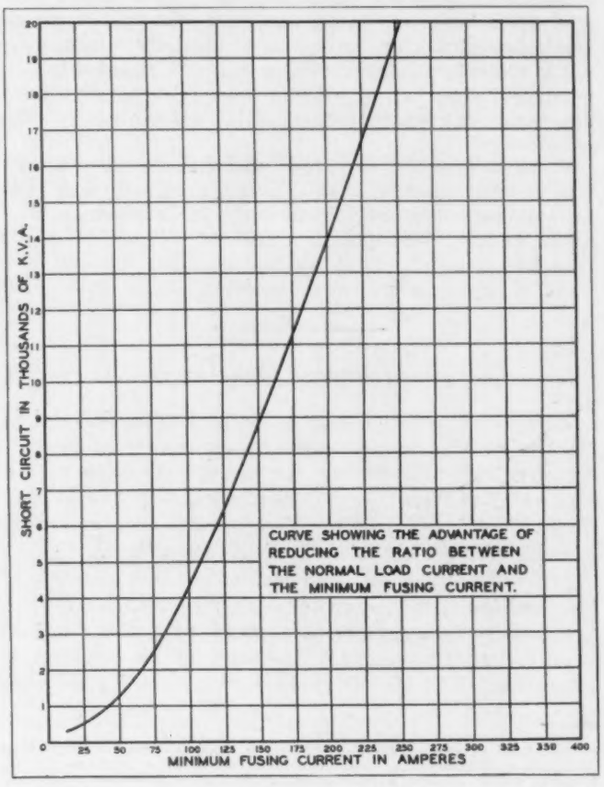
SHORT CIRCUIT IN THOUSANDS OF K.V.A.
MINIMUM FUSING CURRENT IN AMPERES
CURVE SHOWING THE ADVANTAGE OF REDUCING THE RATIO BETWEEN THE NORMAL LOAD CURRENT AND THE MINIMUM FUSING CURRENT.

*Fig. 2. Curve showing the advantage of reducing the ratio between the normal load current and the minimum fusing current.*

rated cutouts, the cutout either blew to pieces or was unfit for service. These tests lead to the conclusion that cutouts rated at 60 amp. should not be used where the short circuit current may exceed 1,000 amp. and the large cutouts rated at 150 amp. should not be used where the short circuit current may exceed 2,000 amp.

### Fusing of Transformers

It is the practice of most of the member companies to fuse to clear the transformer from the line in case of burnout or secondary short circuit and not to fuse the transformer for protection from small or momentary overloads. For 2,300 and 4,400-volt primaries, the ratio of fuse rating to transformer primary current varies from 1.8 to about 2.5. The short circuit kva. which the cutout has to interrupt increases very rapidly as this ratio is increased, as shown in Fig. 2.

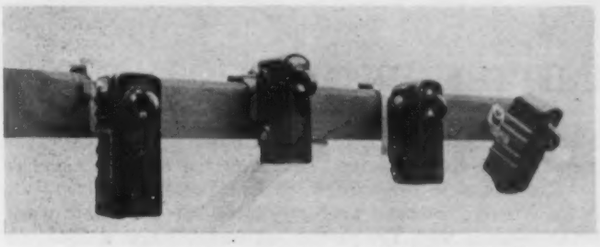

*Fig. 3. Closed view of 60-amp. 5,000-volt cutouts.*

However, several companies report that they increase this ratio to 3.5 for power installations and some special types of load. The adoption of this higher fusing ratio has resulted in a greatly reduced number of outages due to fuse-outs, with a resultant of more satisfactory service to the consumer. These consumers, usually engaged in commercial business, suffer considerable inconvenience and economic loss through outages and it is felt that the reduction of the margin of safety from transformer burn-out and the increased severity of operation imposed upon the cutout due to the higher fusing is more than justified by the improved service.

### Fusing of Branch Lines

The fusing of branch lines in general does not seem due to the difficulty of determining the proper fuse to use. Also, it often happens that trouble will occur in the day time, causing the branch line fuse to blow but, as none of the consumers are using energy, they and the company are both unaware of the outage until evening when the service is required. This handicaps the troubleman who has to work in the dark and of course prolongs the outage. Most of the member companies only fuse branch lines located in hazardous locations, such as creek bottoms, trees adjacent to the line, etc.

The new link previously referred to appears well qualified for branch line fusing as its time lag is not sufficient to cause the relay in the main circuit to function nor is the time lag so short as to cause the fuse to blow on momentary overloads. With the advent of this fuse link, branch line fusing may become of more general use. In our opinion, the fusing of three-phase branch lines supplying a mixed three-phase and single-phase load, with the single-phase load predominating, is not desirable due to the troubles caused by the opening of one phase only, and in no case should the size of the branch line fuse exceed 50 amp.

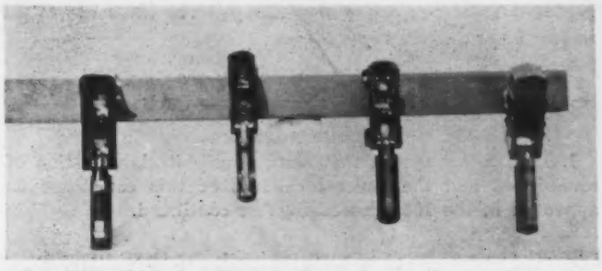

*Fig. 4. Open view of 60-amp. 5,000-volt cutouts.*

### Cutout Application

The field of application of the plug type cutout is growing very limited due to the inability of this cutout to interrupt moderate short circuit currents, its tendency to cause radio interference and the necessity of using a special mounting insulator if used in territory adjacent to the ocean. Some companies have discontinued the use of this cutout entirely and are replacing all of this type cutouts on their system with porcelain box type expulsion cutouts. Other companies are using it on 2,300-volt transformers of 15-kva. capacity or less in dry territory and in all territory as the neutral disconnect (coppered) on 4-kv. "wye" systems.

All companies use an enclosed cutout on 4-kv. lines and open type for 6.6 kv. and over. For 4-kv. use the trend is toward a porcelain housed circuit with the fuse holder mounted on a door opening downward, the entire fuse holder being dead when the door is opened.

One company, operating in a large area and encountering a wide variety of climatic conditions, has found it advisable to divide this territory into a number of insulation districts. The district adjacent to the ocean requires cutouts with high insulation due to the fog and damp air. The other districts require less and less insulation as they work back into the arid valleys.

When the size of individual transformers reaches 100 kva. or more, it is the general practice to use liquid or oil immersed fuses. Some companies are installing oil switches with overload trip coils on installations of this size.

### Fuse Tubes for 6.6 to 22-kv. Lines

Due to using open type cutouts for lines of this voltage, which of course exposes the fuse tube to the weather, a great

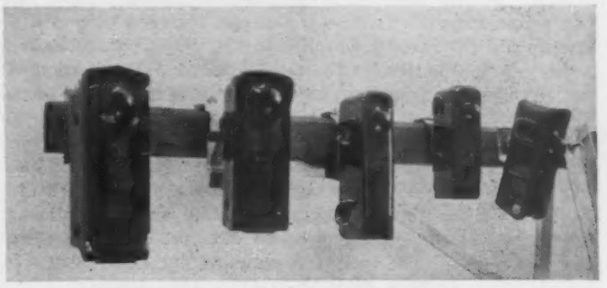

*Fig. 5. Closed view of 150-amp. 5,000-volt cutouts.*

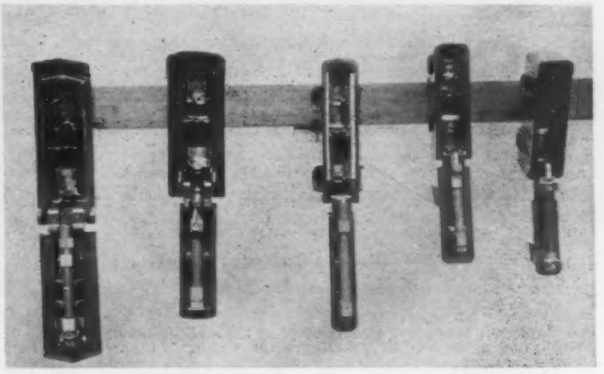

*Fig. 6. Open view of 150-amp. 5,000-volt cutouts.*

deal of trouble is experienced due to the fuse tube absorbing moisture and thus increasing the leakage current; in some cases to such an extent that the fuse tube becomes badly charred.

These fuse tubes are usually made of horn fiber or Bakelite. The horn fiber when dry will stand an arc better than the Bakelite but it absorbs moisture more readily. Due to these disadvantages, some companies have experimented with glass and porcelain tubes but they have not as yet proved practical due to their lack of mechanical strength resulting in large breakage. There is also the hazard of personal injury to the troubleman if the tubes break while being installed or removed from the cutout; particularly so if the fuse blows while being installed.

It is common practice to varnish the fiber fuse tubes to prevent the absorption of moisture. The frequency of this varnishing depends upon the climatic conditions; a fuse tube exposed to damp air requires more frequent varnishing than one located in a dry atmosphere.

#### Replacement of Fuse Links

Much confusion and many unnecessary second outages have occurred due to troublemen replacing only the fuse that has blown on transformer fuse-outs. It is much better practice to replace all of the fuses on the transformer, or transformers, in case of a power bank, as the other fuse or fuses are apt to have been weakened at the time the first one blew and another outage is likely to result the first time a momentary overload is thrown on the transformers. Fuses are subject to oxidation and it may be possible that the fuses have been installed for so long a time that this oxidation has weakened them. It is also found that inexperienced men often install fuses of incorrect size and the replacement of all the fuses corrects this error.

# PRIME MOVERS COMMITTEE REPORTS[2]

## *Prime Movers Committee Activities**

THE growing importance of this committee in the activities of the Pacific Coast Electrical Association has been reflected in the interest taken in the discussions and the increased attendance at the regional meeting this year.

The marked increase in efficiency of steam plants since the advent of higher steam pressures, extraction feed water heating and preheating of air for combustion, has made steam-electric power a close competitor of hydro-electric power. The building of modern high-pressure steam plants, both in southern California and in the San Francisco Bay region, has greatly enhanced the interest taken in the work of the prime movers committee.

The public utilities of the State of California produced by steam generation 2,144,613,000 kw.-hr. during the year 1930. This was approximately 25 per cent of the state's output of electrical energy and required the burning of 26,000,000,000 cu.ft. of natural gas and over 1,000,000 barrels of fuel oil. The prime movers committee, through its reports and discussion and the data it supplies to the national association, is the principal outlet for the publication and distribution of the technical investigations and research of this very large industry.

The subcommittee reports for this year have been confined more closely than is usual to operating problems. The new 100,000-kw. unit at the Long Beach steam station of the Southern California Edison Company Ltd. and the Hunters Point plant of the Pacific Gas and Electric Company were placed in operation early in the year and operating data for these plants have been available for this year's report.

The 1,400-lb. installation at Station A of the Pacific Gas and Electric Company, consisting of two 50,000-kw. units, has been under construction throughout the year and was placed in operation early in 1931. Design features were published in previous reports and the period of operation has been too short to supply data for the present report.

Eight subcommittees were appointed for the year's work in accordance with the permanent classification adopted in 1930. For this year three of the subjects under the permanent classification were combined into one subcommittee on "Turbo-Generators, Condensers, Boilers and Auxiliaries."

Final reports are presented herewith of six of these subcommittees, as follows:

1. Review.
   Advisory subcommittee.
   Round table discussions.
   Serial method of submitting reports.
2. Turbo-Generators, Condensers, Boilers and Auxiliaries.
   Turning gears.
3. Instruments, Automatic Control and Plant Records.
   Failure in an automatic combustion control system.
   Operation of $CO_2$ recorders.
   Operation of combustion control and boiler meters.
4. Operating and Maintenance Practice.
   Rules for oil and gas firing.
5. Heat Balance, Design and Plant Betterment.
   New Pacific Coast installations.
   Obtaining boiler efficiency by heat balance.
6. Water Conditioning and Power Plant Chemistry.
   Feed water conditioning in Pacific Coast plants.

Two other subcommittees have been at work during the year covering the subjects "Station Piping" and "Plant Management." It is expected that final reports on these subjects will be available during the coming year.

---

## *Report of the Subcommittee on Review**

*This report contains certain recommendations for the organization of the prime movers subcommittee for the years* 1931-32, *and suggestions regarding the conduct of regional meetings, all along the general lines approved in the* 1930 *annual report.*

THE following recommendations covering the prime movers committee organization have been made:

#### Recommendations

1. It is recommended that the permanent classification of committees and the general conduct of this committee as approved in the 1930 proceedings be continued.

---

[2] C. H. Delany, Pacific Gas and Electric Company, chairman. L. J. Kraps, Southern California Edison Company Ltd., vice-chairman.
General Electric Company: R. F. Monges.
Hawaiian Electric Company, Ltd.: L. A. Hicks.
Leeds and Northrup Company: N. Cohn.
Los Angeles Gas and Electric Company: M. R. DeLisle, F. R. Knight, E. G. McDonald, J. G. Rollow, H. E. Thompson, C. H. Zeise.
C. C. Moore and Company Engineers: D. P. Vail.
Pacific Gas and Electric Company: L. D. Burlingame, P. E. Chapman, V. F. Estcourt, H. S. Markey, H. N. Mosher, J. S. Moulton, M. E. Mulkey, W. N. Munro, R. C. Powell, J. M. Renfrew, C. E. Steinbeck, F. B. Stillwagon.
San Diego Consolidated Gas & Electric Co.: E. D. Sherwin, C. W. Wiggins.
San Joaquin Light & Power Corporation: A. Y. Meudell, C. P. Rhine, H. T. Shirley.
Southern California Edison Company Ltd.: J. W. Andree, H. C. Bennett, Scott Jensen, F. G. Philo, A. Sattler, W. H. Short, R. A. Wallingford, R. Wilcox.
The Southern Sierras Power Company: V. E. Johnson.
Westinghouse Electric & Manufacturing Company: C. H. Brunner.

* Report of C. H. Delany, chairman prime movers committee.

* Report of the subcommittee on review, prime movers committee, Engineering Section. Leo. J. Kraps, chairman, V. F. Estcourt, Scott Jensen, F. R. Knight, H. S. Markey, C. W. Wiggins.

2. It is suggested that an advisory subcommittee be added to include the superintendents or operating heads of the steam generation departments in the member companies. Their duties would be:

(*a*) To select the personnel from their own company to serve with the subcommittee chairmen as appointed by this association.

(*b*) To suggest through the chairman of the prime movers committee, topics of timely interest for subcommittee investigations.

(*c*) To report to the chairman of the prime movers committee special tests and reports originating in their company which might be of value to the subcommittees functioning that year.

(*d*) To suggest and outline in advance of the regional meetings, topics for the round table discussion as suggested.

3. It is suggested that the informal round table discussions, which have gradually developed at our meetings, be encouraged and developed.

(*a*) That certain subjects be suggested for these discussions, and the membership be advised in advance of their nature so all can be prepared to take an active part.

(*b*) That this part of the meeting shall be open for the free discussion of any subject that may be advanced without its necessarily having been programmed in advance.

(*c*) That these discussions should not be reported, or at least should be carefully edited to insure that any detrimental or objectionable statements are not broadcast.

(*d*) That subjects arousing particular interest be recorded and used to some extent as a basis for subcommittee investigations.

4. It is recommended that a serial method of submitting final reports be adopted, certain designated reports to be presented in their final form at each regional meeting, at which time this subcommittee could be discharged and their successors appointed, subject to the approval of the vice-chairman of the prime movers committee. It is our thought that this will relieve the congestion of reports at the end of the year, give a longer time for discussion of each report, and once initiated, will still allow a full twelve months' period for their preparation.

---

# *Turbo-Generators, Condensers, Boilers, and Auxiliaries**

*The purpose of this subcommittee this year has been to bring up for discussion faults found in the construction and arrangement of the various parts of the steam plant which produce unsatisfactory operation. It has been thought inadvisable to publish these discussions.*

*Through the efforts of C. H. Brunner of the Westinghouse Electric & Manufacturing Company a paper on "Turning Gears" for turbines has been prepared by T. C. Rathbone of the Westinghouse South Philadelphia works. This subject has a great deal of interest for members of the prime movers committee and is presented herewith.*

## *Turning Gears*

### Function of Turning Gears

BEFORE the sizes of turbines had reached the proportions attained within recent years, there was little need for special means to permit quick starting. The smaller, lighter spindles with lesser heat inertia could be straightened fairly rapidly and the unbalance due to whatever distortion remained was relatively small. Consequently the amount of time necessary to bring such units to speed and put on line was within reasonable amounts.

As capacities increased and spindles became longer and heavier, more time became necessary to "roll out" the distortion due to unequal heating. The straightening had to be carried to closer limits, as a unit of eccentricity produced a greater amount of unbalance. This, with the greater heat inertia, lengthened the necessary "rolling out" time to periods which often became objectionable.

When the turbine is taken out of service and the spindle allowed to stand, the hot gases collect at the top. This stratification produces unequal cooling of both spindle and cylinder. The underside of the spindle cools more rapidly than the top, and the maximum differential is reached on our large sizes in from eight to twelve hours. The curves shown on the upper chart in Fig. 1 illustrate this in a simple way. The spindle (and also the cylinder) distorts upward, and the maximum distortion agrees with the time of maximum temperature differential. After this peak is reached, the differential and hence the distortion, slowly become less, and the spindle finally returns straight after a period of two or three days, when the turbine temperatures equalize.

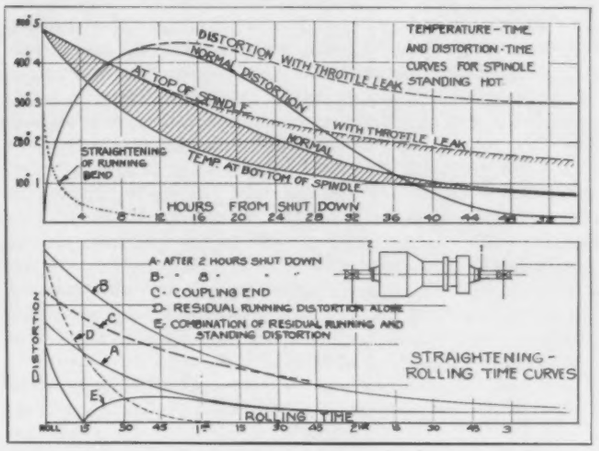
TEMPERATURE - TIME AND DISTORTION - TIME CURVES FOR SPINDLE STANDING HOT
DISTORTION WITH THROTTLE LEAK
NORMAL DISTORTION
AT TOP OF SPINDLE
WITH THROTTLE LEAK
NORMAL
STRAIGHTENING OF RUNNING BEND
TEMP. AT BOTTOM OF SPINDLE
HOURS FROM SHUT DOWN
A- AFTER 2 HOURS SHUT DOWN
B- " 8 " " "
C- COUPLING END
D- RESIDUAL RUNNING DISTORTION ALONE
E- COMBINATION OF RESIDUAL RUNNING AND STANDING DISTORTION
DISTORTION
STRAIGHTENING - ROLLING TIME CURVES
ROLLING TIME

*Fig. 1. Curves showing distortion of spindle after taking turbine out of service.*

The maximum distortion of the shaft, as measured at the exposed gland space, may vary from two to five thousandths of an inch. If during the shut-down period any steam has access to the cylinder, due to leaky throttle or other sources, the distortion may exceed these limits and, furthermore, the spindle will never become straight as long as the leak exists. Curves with a leaky throttle are illustrated.

If the turbine does not have to go in service again before temperature equilibrium has been reached, then the length of time required to bring up and place on line is limited only by that required for the necessary warming up to prevent undue axial differentials between the spindle and cylinder. With the reaction turbine, these "side" clearances are fairly generous. But if it becomes necessary to place the unit in service while the spindle distortions from standing are still appreciable, then the spindle must be rolled slowly to straighten it to within an amount which will permit coming to speed without undue vibration.

We provide shaft truth indicators which are mounted outside the gland cases to show the amount of distortion with the spindle rolling slowly. Although units vary considerably, it is found that a reading on the indicator to within about 0.0015 to 0.002 (double eccentricity) should be reached before attempting to bring the spindle to speed. A greater amount usually results in sufficient unbalance to produce objectionable vibration in passing through the usual foundation and turbine resonance speeds encountered between 1,100 and 1,400 r.p.m.

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* Report of the subcommittee on turbo-generators, condensers, boilers and auxiliaries, prime movers committee, Engineering Section. C. E. Steinbeck, chairman, C. H. Brunner, R. F. Monges, J. M. Renfrew, E. D. Sherwin, H. E. Thompson, D. P. Vail, R. Wilcox.

Although a number of the larger units can be depended on to get on line within an hour, some have required two days or more, by reason of suffering greater distortion and having slower straightening properties. The cause of this difference is not clear. Modern central station practice makes it desirable to be able to place a unit in service at least within an hour. Incidentally, it may be mentioned here that excessive heating of the exhaust casing during long rolling periods can be eliminated by adopting the practice of bringing the speed up to 400 or 500 r.p.m. and closing the throttle, allowing the spindle to coast down, and repeating before the spindle comes to a stop, until the shaft is straight.

It should be recognized that the factors making for longer starting periods are penalties for increasing the size and capacities of units, and therefore any special means necessary to reduce this starting time are legitimate and quite justified.

When the difficulties due to cylinder and spindle distortion from stratification began to develop, we provided a means for circulating the gases in the cylinder, using compressed air introduced into the cylinder through several nozzles, the prime object being to prevent stratification and thereby reduce both cylinder and spindle distortion. At that time, a few cases of cylinder distortion were encountered which were sufficient, in conjunction with the bent spindle, to cause a blade rub when first rolling over. The air circulation method has helped greatly in reducing the starting distortion and necessary rolling time, and in some cases has been a valuable means for reducing the humping tendency of the cylinder. We have continued to provide this equipment up to the present time, although it has not proved universally satisfactory. Because of the impossibility of obtaining perfect circulation (air passing through the glands, etc.), the desirable minimum of spindle distortion was not uniformly attained. To accomplish this aim in the simplest and most effective way, means for rotating the spindle have been developed.

Such equipment is not new. Probably the first application of a turning over arrangement was made on marine turbines where the custom of preliminary or periodic rolling over developed, to assure operability when needed. The navy specifications have required such equipment for some time. The marine spindle turning gear, however, is usually of the worm and wheel type and engaged by hand, and not intended for continuous operation.

We have provided two methods of turning the spindle to maintain straightness for central station application—first the jacking gear, by which the spindle can be turned small amounts, at desired intervals, and second, the turning gear, for continuous slow rotation by motor drive.

### Jacking Gears

A typical jacking gear is shown in detail on Fig. 2 and the assembly in the coupling end bearing pedestal on Fig. 3. Oil, at 400-lb. pressure, controlled by a 3-way cock (either manually or automatically, as will be described later) is supplied to the operating piston, which forces upward the pawl B. As the pawl rises, the spring C pushes it to the right, engaging the ratchet teeth on the coupling, and the shaft is given a partial turn. When the cock is turned to the other position, the oil under the plunger is released, allowing it to drop. Before the bottom position is reached, a lug on the pawl strikes the top of the cylinder, forcing it to the left and out of the way of the ratchet teeth. This is the normal position during operation.

The oil supply for the jacking gear is furnished by a 400-lb. pump, having a capacity of 17 g.p.m. at that pressure. The pump is driven by a 7½-hp. high torque starting motor. An air dome mounted near the pump provides the necessary elasticity for imparting a uniform acceleration to the rotors.

A few minutes after the spindle comes to rest, the remaining oil film under the journals from normal operating lubrication is pretty well squeezed out. A considerable torque is then necessary to start the rotors turning. Heavy cylinder oil greatly reduces the starting friction, but its use is not practical. To overcome this starting difficulty with the use of the jacking gear, we have provided an auxiliary high pressure lubricating system, which functions only when the jacking gear is in use, and is cut out of operation when the turbine goes in service with its regular lubrication.

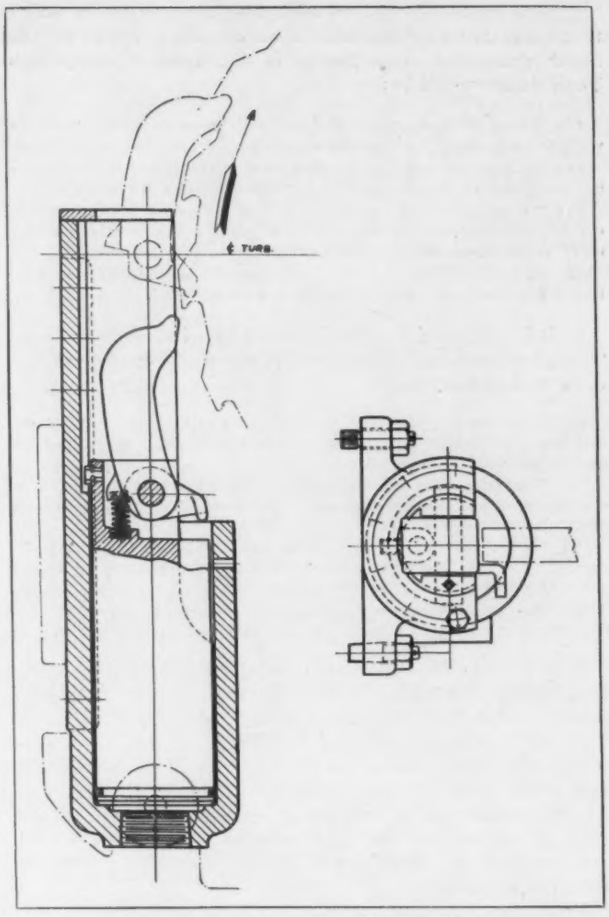

*Fig. 2. A typical jacking gear for turning spindle small amounts.*

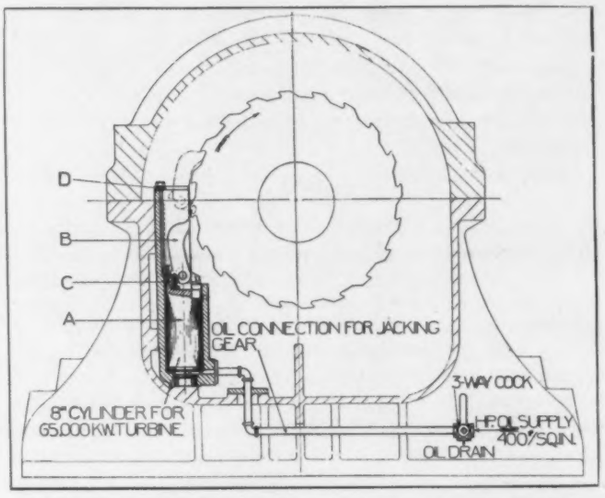


*Fig. 3. Assembly of jacking gear in the coupling and bearing pedestal.*

### High Pressure Lubrication

The method of adaption of our regular bearings for the high pressure lubrication is shown in Fig. 4. Two high pressure nozzles are supplied on each of the present bearings. The auxiliary high pressure oil is supplied by a 1,400-lb. pump, having a capacity of 4 g.p.m. and driven by a 5-hp. high torque starting motor. For the usual installation, a 4-cylinder pump is employed, an individual cylinder for each main bearing. Although on one installation the four cylinders pumped with a common manifold supplying the four bearings, the individual supply for each bearing is recommended. The high pressure oil actually lifts and floats the shafts and reduces the starting torque to the absolute minimum. The heaviest spindles can easily be started and kept rolling by one man pulling on the blades.

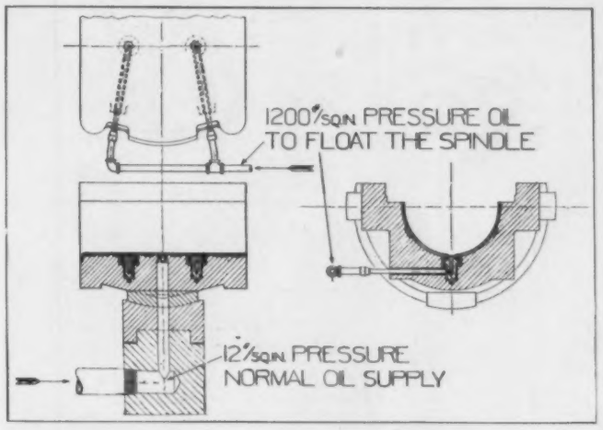


*Fig. 4. Method of adapting bearings for high pressure lubrication.*

Attention is called to the method of installing the high pressure nozzles in the standard bearings, by imbedding the brass tips in the babbitt as shown in the drawing supplied. There is no likelihood of the high pressure oil getting under the babbitt and forcing it tight against the journal. Also, the high pressure oil installation interferes in no way with regular operation.

There is no danger whatever of the high pressure oil lifting the shafts high enough to cause interference. The capacity of the pump is very low, and the maximum film thickness built up is only four or five thousandths of an inch. This is automatically maintained by the load on the bearing and the viscosity, which determines the quantity of oil flowing in the film. The pressure builds up until this equilibrium is reached. A sufficient margin is obtained with the 1,400-lb. pumps. Air domes at the pumps insure a fairly continuous supply, and prevent the journals dropping to the babbitt each stroke.

The jacking gear unit then consists of the hydraulic jack operated by a 400-lb. pump and a high pressure lubrication system in conjunction with it, supplied by a 1,400-lb. pump. The two pumps can be provided in one unit.

### Methods of Using Jacking Gear

There are two or three methods of using the jacking gear in service. As has been shown, the spindle standing hot tends to bend upward at a rate which, rapid at first, becomes constant between eight and twelve hours after the shutdown (causing the maximum distortion at this time) and then falls off at a slower rate. Some operators simply reverse the spindle (turn it through 180 deg.) at arbitrary intervals and continue this until no further objectionable distortion occurs.

By another method the shaft is automatically turned through small increments at frequent intervals. A timing device and relay is used. When this plan is followed, it is necessary to limit the periods between turns to an amount which will not produce excessive distortion at 180 deg., 540 deg., etc., from the initial position. In other words, after one-half turn every full turn thereafter may be beyond the limits required to bring the unit to speed at once, and thus defeat the attempt to maintain immediate availability for emergency. This plan is not generally recommended.

As the spindle at rest distorts upward in approximately the vertical plane, the 180-deg. reversal is the most logical method for using jacking gears, but these reversals should be timed in such a way that the maximum benefit is obtained. Obviously, it would be improper to reverse the spindle before it has passed through the neutral position from the previous period.

In Fig. 5 (upper figure) the attempt is made to show an ideal method of timing the reversals by which the spindle is kept in the immediately available condition, with the most economical use of the jacking gear.

The method is based on an experimental determination of the distortion-time curve. A limit is then set for the maximum permissible distortion with which the spindle can be brought to speed without objectionable vibration. (It is assumed that these distortions are based on the shaft indicator readings.) An assumed distortion-time curve is shown in the drawing. Then, if 0.0012 in. is the limit adopted, the spindle must be reversed about 30 minutes after the shutdown. Then, as there would be no point in reversing before the spindle axis has passed through the neutral point and distorted the limited amount in the opposite direction, it is allowed to stand for five and one-half hours and then reversed. This process is continued, using the change in distortion from point to point on the curve determined by experiment, until the time is reached when no further reversal becomes necessary. This computation assumes that the rate of bending (differential cooling) is the same for each position, which, of course, is not quite legitimate. The rate of cooling depends on the difference in temperature between the spindle surface and the surrounding gas. It is also assumed that the distortion occurs in the exact vertical plane each time.

It will be noticed that the reversal periods are short at first and become longer with time. An ingenious plant operator

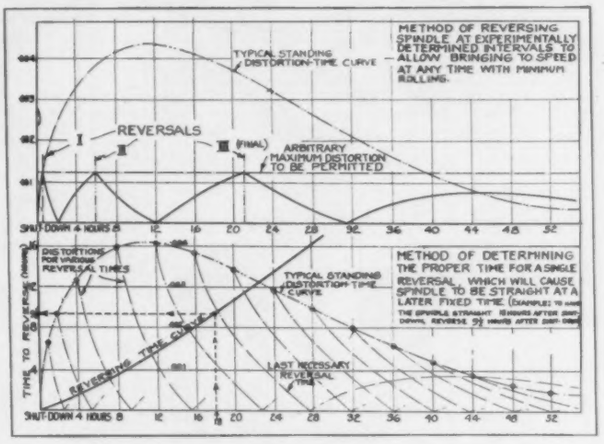
METHOD OF REVERSING SPINDLE AT EXPERIMENTALLY DETERMINED INTERVALS TO ALLOW BRINGING TO SPEED AT ANY TIME WITH MINIMUM ROLLING.
TYPICAL STANDING DISTORTION-TIME CURVE
REVERSALS
I
II
III (FINAL)
ARBITRARY MAXIMUM DISTORTION TO BE PERMITTED
SHUT-DOWN 4 HOURS
METHOD OF DETERMINING THE PROPER TIME FOR A SINGLE REVERSAL WHICH WILL CAUSE SPINDLE TO BE STRAIGHT AT A LATER FIXED TIME. (EXAMPLE:
DISTORTIONS FOR VARIOUS REVERSAL TIMES
TYPICAL STANDING DISTORTION-TIME CURVE
REVERSING TIME CURVE
LAST NECESSARY REVERSAL TIME
TIME TO REVERSE (HOURS)
SHUT-DOWN 4 HOURS

*Fig. 5. Curves showing method of timing reversals of spindle with jacking gear.*

could easily arrange for reversals at the proper time by automatic means, using a clock and a relay.

If there is positive assurance that a turbine which has been taken out of service will not be put on line again until a later fixed time, then a single reversal can be made after a computed period has elapsed, which will cause the spindle to return straight at the desired time. These data are determined experimentally from observations on a number of

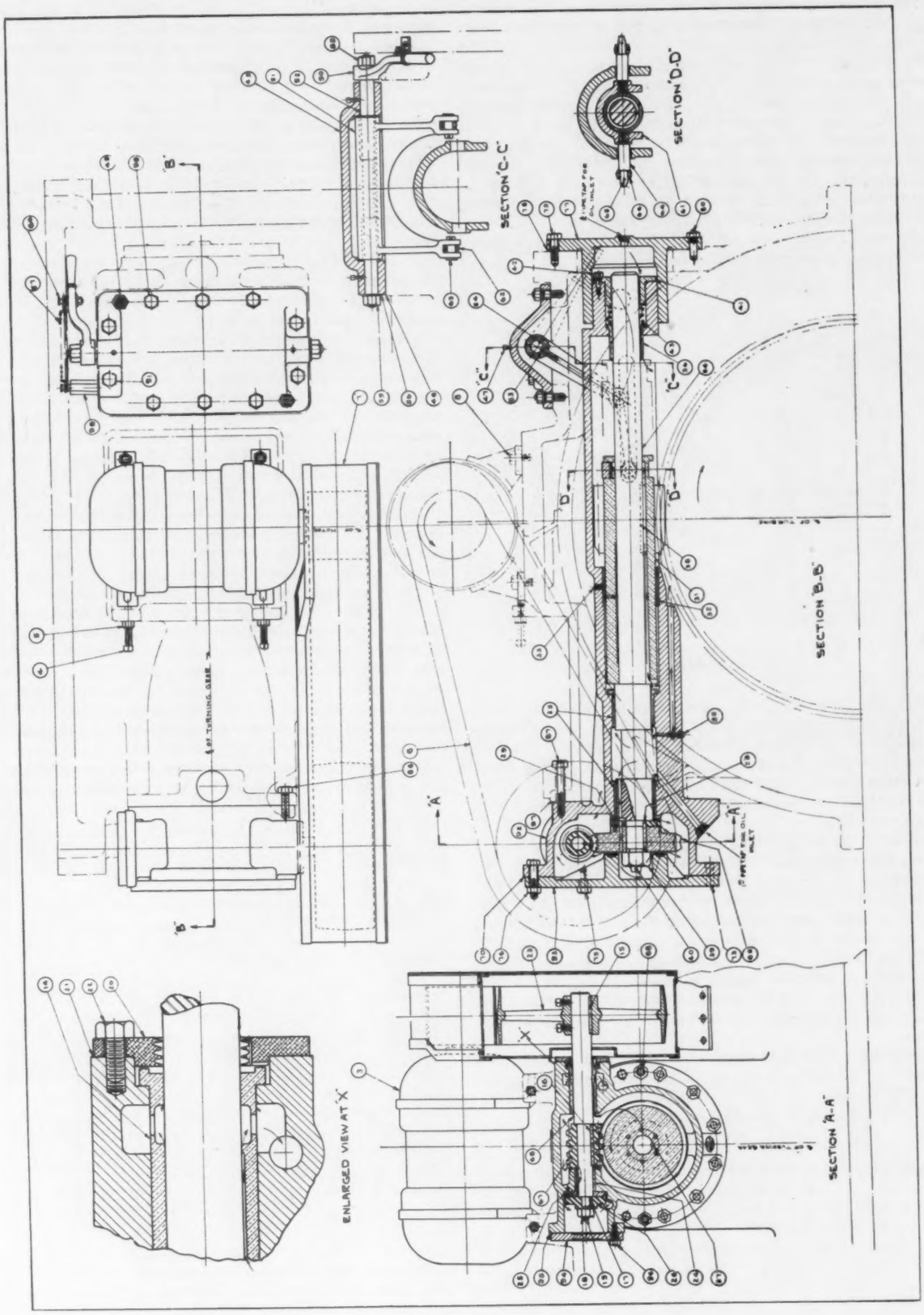


*Fig. 6. A typical turning gear assembly.*

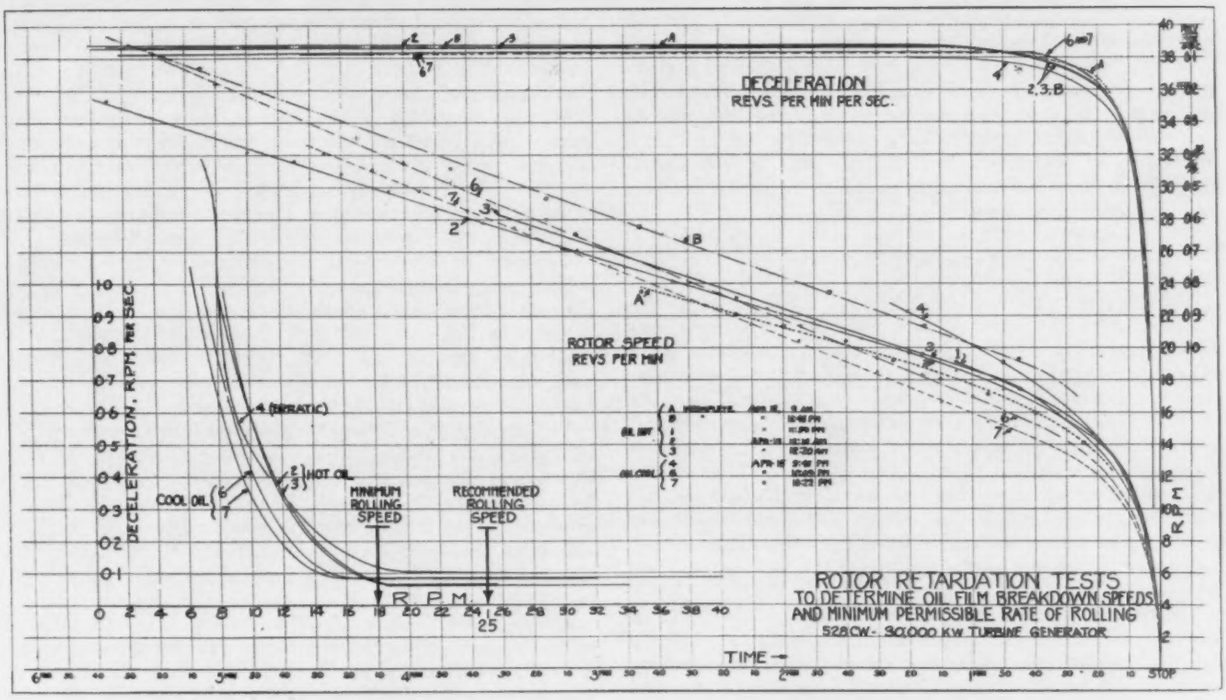


*Fig. 7. Curves showing results of tests to determine oil film breakdown speeds.*

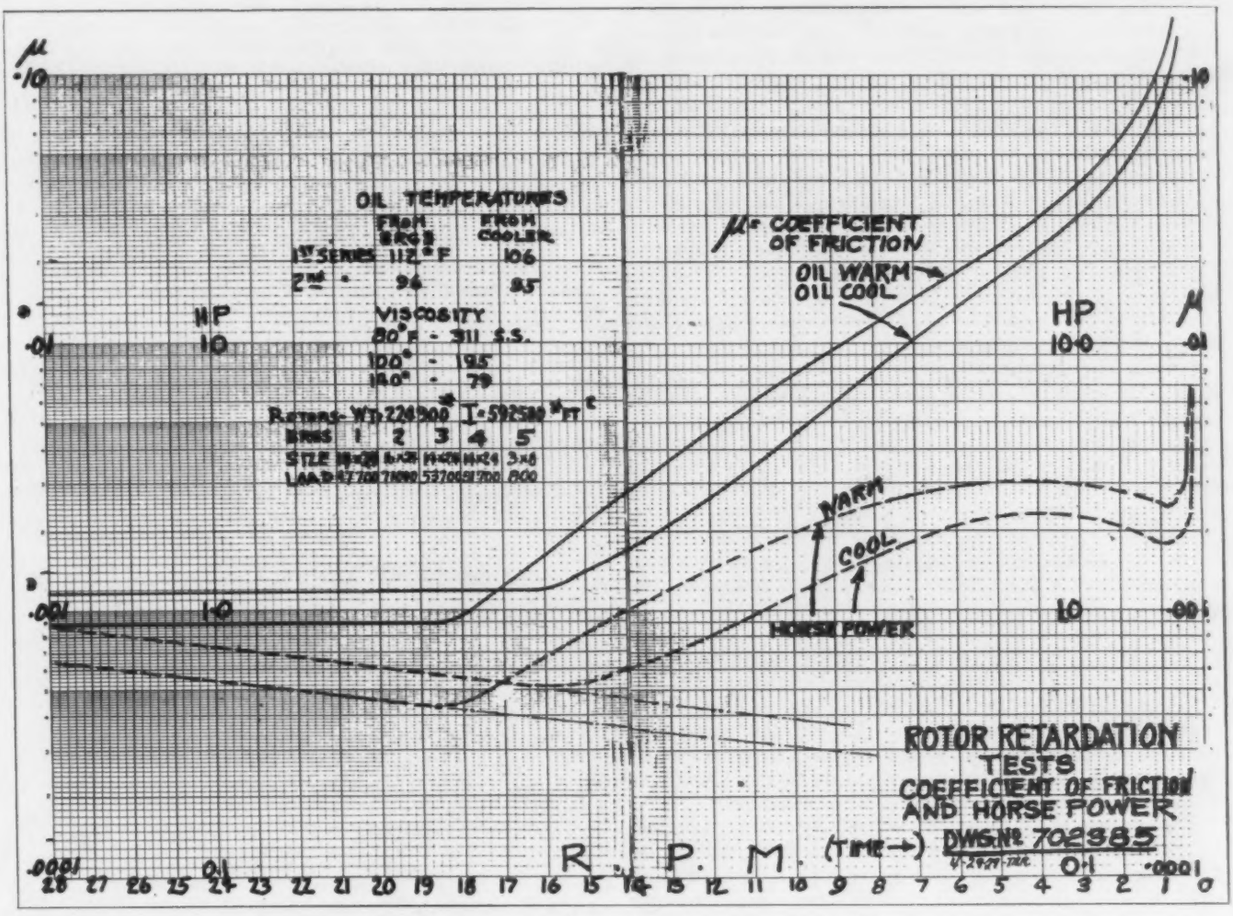


*Fig. 8. Curves showing results of rotor retarding tests.*

shut-down periods, allowing the spindle to stand for various lengths of time, and then testing the eccentricity at intervals after the reversal, to find the time when the spindle becomes straight. When sufficient data have been obtained, a curve can be constructed as shown on Fig. 5 (lower chart) with the lengths of shut-down as the abscissa and the time to reverse as the ordinates. The general objection to such a method is, of course, the fact that the unit is immediately available without wasting time in rolling to straighten only near one particular time.

### Turning Gears

The foregoing methods assume ideal and consistent distortion. Actually, other factors enter which prevent such close predictions of the distortion at any given time under all conditions and, therefore, an element of uncertainty does exist in such attempts to insure immediate availability. Although the reversal method by jacking gears unquestionably reduces the starting time, if great care is used in making an exact half turn (which is difficult) the only positive method for preventing all distortion and securing the best possible condition for starting, lies in rolling the spindle slowly and continuously during the period when the temperature distortions exist. (An ideal auxiliary use of the jacking gear will be described later.)

For this purpose we have provided turning gears as standard equipment on the larger machines. Fig. 6 shows a typical turning gear assembly, which is mounted on the coupling end bearing cover. The motor, usually 10-hp. rating, drives the worm (67) through belt and pulleys. This worm drives a worm wheel (69) and shaft (34), which in turn carries a worm sleeve (31), arranged with a key (38) for sliding along this shaft. The position of the worm is controlled by a hand lever (50). The worm is the extreme left position engages teeth "F" provided on the coupling, by which the spindle and rotor are turned at a speed of approximately 25 r.p.m. When the worm sleeve is at the extreme position to the right, it is completely disengaged from the coupling teeth.

By reason of the worm and coupling teeth angle, the thrust is to the left with full engagement when the motor is driving the spindle. When the corresponding motor speed is less than the spindle speed (i.e., when the spindle is attempting to drive the motor), the thrust on the worm is to the right and it automatically slides over and out of the way. An oil dash pot is provided as a shock absorber to take care of the impact from this movement.

In practice, the worm is thrown in mesh manually by the hand lever when the spindle speed has coasted down slightly below the driving speed. It cannot be forced into engagement when the spindle speed is too high. Except in isolated cases it is not possible to start the spindle from rest by means of the motor and gear. Depending on a number of things (oil viscosity, weight on bearings, etc.) the turning gears can pick up and accelerate the spindle to the normal rolling speed from just starting to 10 or 15 r.p.m. It is usually necessary to turn over turbine at rest by steam until sufficient speed is reached for the gear to take hold.

The addition of the auxiliary high pressure lubrication previously described has made it possible to start from rest with the turning gear on all but the larger units. The further addition of the hydraulic jacking gear assumes independence from steam in starting and this ideal combination has been supplied on the frames. However, recent improvements in the driving gear are making it possible to start from rest without the hydraulic jack gear.

The turning gear is designed to roll the turbine at about 25 r.p.m. The actual lower unit of speed at which the normal oil film commences to break down varies, of course, with viscosity and load. Friction increased rapidly below this point, and it would be improper to attempt to operate in this region. Tests where a particularly heavy oil is used indicated that film breakdown occurred around 7 r.p.m. A rather elaborate test carried out with a lighter oil showed the film breakdown speed was about 17 r.p.m. The curves shown on Fig. 1 and Fig. 8 describe the results of the tests. The speeds were determined with the oscillograph, recording one-hundredths of a revolution, and are, therefore, very exact. As a result of such tests, the rolling speed of about 25 r.p.m. has been adopted as being the minimum permissible for the sake of economy in driving power, and yet having sufficient margin above the film breakdown speed below which the power necessary for driving again increases.

On most of the present installations equipped with the rolling gear, the standard auxiliary oil pump is operated to provide lubrication. A special motor-driven oil pump supplying the bearings with oil at 5 lb. has been installed on a 110,000-kw. unit for use when the turning gear is in operation. This was done for the sake of economy over the regular steam-driven auxiliary pump.

The turning gear is becoming increasingly popular as its advantages are demonstrated. As has been stated, the combination of turning gear and high-pressure oil floating the journals for starting is ideal. The jacking gear adds further convenience for turning through small angles. Some minor difficulties encountered on the first installations, such as belt slipping, etc., have been effectively eliminated by later improvements.

Although the feature of quick staring has been stressed in the foregoing description, a further advantage in preventing spindle and cylinder distortion by rolling, should not be overlooked, and that is the practical elimination of blade rubs from distortion at starting, and the consequent preserving of the initial efficiency.

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## *Instruments and Automatic Control**

*This report lists in detail all failures occurring on the automatic combustion control supplies for the six 3,416-hp. boilers of the Long Beach steam station of the Southern California Edison Company Ltd., during the first eighteen months' operation.*

*It also includes operating and maintenance reports on $CO_2$ recorders, boiler meters, and combustion control from Station C and Station P of the Pacific Gas & Electric Company.*

THE principal feature of this report is a comprehensive statement by a member company, covering actual failures of the many parts of a combustion control over a period of several years, together with remedies, changes and suggestions relative thereto. The report also contains a brief statement covering the operation of combustion controls, and combustion recorders.

### *Statement of Southern California Edison Company Ltd. On Automatic Control Equipment*

#### Description, Failures and Remedies

*Description*

Automatic control equipment covered in this report consists of the following items:

2 master control panels complete with:
- 1 3-point drum switch
- 1 master contactor equipped with 1/20-hp. motor
- 1 master differential relay (duplex)

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* Report of the subcommittee on instruments, automatic control and plant records, prime movers committee, Engineering Section. H. S. Markey, chairman. H. C. Bennett, P. E. Chapman, M. R. DeLisle, M. E. Mulkey, R. A. Wallingford.

1 interrupter contactor equipped with 1/20-hp. motor
1 3-pole S.T. knife switch with attached fuses
2 2-pole S.T. knife switches with attached fuses
1 master pressure recorder with synchronous clock.

6 boiler control panels complete with:
1 6-point drum switch
1 differential relay
1 boiler meter (double case type) equipped with:
(*a*) furnace draft readjustment contactor
(*b*) steamflow airflow readjustment contactor
(*c*) gas pressure compensation
(*d*) steamflow recording mechanism range—0—450,000 lb. steam at 450 lb. per sq.in. and 750 deg. F. total temperature
(*e*) airflow recording mechanism

3 3-pole S.T. knife switches inclosed in separate panel
1 2-pole S.T. knife switch inclosed in separate panel
1 8-pole multipointer draft gage indicator
6 fuel control drives with connecting shafting, gears, sprockets, chain and two chronometer valves. Equipped with ¼-hp. motor
6 forced draft fan and damper control drives with connecting shafting, gears, sprockets and chain. Equipped with ½-hp. motor
6 induced draft fan and damper control drives with connecting shafting, gears, sprockets and chain. Equipped with ½-hp. motor.

*Failures and Remedies—*

1. Airflow-steamflow linkage:

(*a*) Knife edge and eye assembly wearing was the cause of four failures. Causes sticking and sluggish action of airflow-steamflow contactor, with resulting hunting of induced draft fan.

Remedy: Replacement of worn parts. Time required 8 man-hours.

2. Helical tubes:

(*a*) Splitting in curvature of helix at edge causing leakage caused two failures.

Remedy: New tubes. Time required 10 man-hours.

(*b*) When replacement tubes were received from factory the small capillary tubing connecting the tube to the gage line was found plugged with some foreign matter. No failures occurred in service as tubes were tested on test bench before installation. Considerable time was expended trying to clean out capillary tubing, with no success. Time required 12 man-hours.

3. Master contactor:

(*a*) Burning and pitting of contacts caused four failures from contact remaining closed.

Remedy: Filing and polishing. New contacts when contact face is destroyed. Time required 26 man-hours.

(*b*) Breaking of negative feed wire to master differential relay contact which energizes the boiler differential relay caused four failures. This interrupts contacts being sent either by master contactor or by push button from the relay with the broken wire. This will allow steam pressure to vary in one direction up or down, depending on which relay is out of service. It is necessary to change all boilers to position 5 and operate on semi-automatic control. Steam pressure control by operator must be resorted to until relay is repaired.

Remedy: Large pigtail and better quality stranded wire. Time required 4 man-hours.

4. Boiler differential relays:

(*a*) The original 3-boiler installation was equipped with relays which proved too light for the continuous intermittent service. Seventeen failures were caused by the breaking of the interlocking contact arms.

Remedy: Heavy duty relays installed. Time required 50 man-hours.

(*b*) Heavy duty relays caused four failures, due to interlocking wire breaking.

Remedy: Large pigtails and better quality stranded wire used. Time required 6 hours.

5. Readjustment contactors:

(*a*) These contactors relay on the small spring located behind the contact assembly to return the contactor to open position after solenoid is energized and released. Springs are of the compression type and are subject to loss of tension after considerable usage. Three failures from this source.

Remedy: Increase of spring tension, and weekly inspection of springs.

(*b*) Due to considerable oil vapor present in meter case where the readjustment contactors are located, twelve failures from burned and pitted contacts have occurred. This oil vapor seems to burn between the contact faces and leaves a very black soot deposit, which apparently increases the arc of the breaking contact. These contacts close and open approximately every eight seconds, causing a considerable quantity of this soot to collect, which necessitates frequent cleaning.

Remedy: New contact points when outer layer of the special contact metal is penetrated. Oil of 1.24 specific gravity is used for the sealing of the airflow bells in the meter casing, which was covered with a small quantity of water. Due to temperatures encountered in meter casing, water evaporated rapidly, leaving a scale and rust formation on bells and meter casing, which was not acceptable. Time required 24 man-hours.

6. Drum switches:

(*a*) The three original boilers were equipped with the standard manufacturer's type drum switches. Six failures occurred due to poor contact. Positions of switch were also indefinite.

Remedy: Heavier contact fingers with auxiliary spring tension were designed and installed. Cogs were increased in depth, giving a very definite indication of switch position. Time required for poor contacts only 12 man-hours. Change-over time unknown.

7. Drive spring for forced and induced fan control drives:

(*a*) Original three-boiler installation was equipped with drive spring wire of 5/32-in. diameter. Failures from broken springs were nineteen.

Remedy: Bendix drive springs were installed in place of coil springs. Time required 60 man-hours for service, 48 hours for change from coil to bendix springs.

(*b*) One bendix drive spring has failed since change-over, but this was probably due to flaw in spring metal.

8. Fuse failures on pilot motors of forced and induced fan control drives:

(*a*) Approximately ten failures from fuses have been encountered on the original three-boiler control. Fuses are of the thermal cutout type. Due to fuses being the same rated amperage as the motors, excessive heat due to atmospheric temperatures would cause fuses to blow.

Remedy: 4.0-amp. fuses were installed. Recommendation that ventilated type motor be purchased for future control drives. Time required 5 man-hours.

(*b*) Approximately fourteen fuse failures have been encountered on this latter three-boiler control with the ventilated motor which is rated at 6.0 amp., with fuses for 7.1 amp.

Remedy: Motors were replaced by 3.0-amp. motors of the ventilated type by motor manufacturer which have given no further trouble from fuses. Time required 25 man-hours.

It is noteworthy to say that no failures from fuses have occurred on the fuel-drive motors, probably because of the cooler atmospheric conditions under which they operate.

9. Gas pressure compensators:

(*a*) Seven failures from this source have occurred on the original three-boiler installation, when changing from gas to oil fuel. When changing gas, burners are cut out and pressure will build up until mercury seal blows, which causes loss of mercury. When burning oil, this compensator is not in service, and does not affect airflow reading or relation, as original calibration is made with oil fuel. When burning gas, however, due to the difference in the amount of air required for the different fuels with the compensator out of service, an apparent high airflow above the steamflow reading is obtained on boiler meter chart. This difference will be adjusted by the steamflow-airflow contactor to unity, which will cause an insufficient quantity of air to enter the combustion chamber. Incomplete combustion will develop, causing a further reduction of steamflow with a further reduction of air. This will continue until the operator becomes acquainted with the condition and rectifies same.

Remedy: Three-way valves were installed in gas pressure compensating line, which are connected to gas burner cock handle. When making change-over from gas to oil fuel, the burner cock having the compensator attachment is closed first This puts the underside of the compensator bell to atmosphere. When changing from oil to gas, the gas cock having the compensator attachment is opened last and when normal gas pressure is obtained for the operating rating. Time required 18 man-hours.

10. Gas chronometer valves:

(a) One failure from this valve occurred on one of the three original boilers. Chain operating sprockets were removed to facilitate some construction of pipe work. Chain was replaced by someone unknown. When control was moving gas valve to regulate output, due to the incorrect relation of the gas valve position, and the fuel drive position, the valve arbor was sheared off by the mechanical stop.

Remedy: Control equipment handled by one man. Time required 16 man-hours.

(b) One failure of chronometer valve was due to valve slipping on shaft which caused lack of sensitivity. This valve is held on shaft by 2½-in. U.S.S. set screws.

Remedy: Two additional set screws, installed. Time required 16 man-hours.

11. Interrupters for steamflow-airflow and furnace draft readjustment contactors caused ten failures, as follows:

(a) One motor burned out.
Remedy: New motor. Time required one hour.
(b) Two failures from scored commutator rings.
Remedy: Refacing of commutator rings by machine shop. This can only be done twice, due to the thinness of the rings. The motor design does not include any feasible way to clean or polish commutator ring while in service. Motor must be taken out of service and dismantled. Time required 6 hours.
(c) Two failures from drive chain breakings.
Remedy: Roller chain installed, replacing wire ladder chain. Time required 4 hours.
(d) One failure from contact breaking.
Remedy: New contact. Time required 1 hour.
(e) One failure from cam roller bracket breaking.
Remedy: New bracket made by machine shop. Time required 6 hours.
(f) Three flexible hose coupling failures from oil soaking.
Remedy: New hose couplings. Time required 3 hours.

12. Mercoid switches:

(a) Nine failures. Three from oxidized mercury and six from accidental breakage.
Remedy: New mercoid switches. Time required 18 man-hours.

13. Pilot motors for control drives:

(a) Failures—One burned out and one motor bearing burned out.
Remedy: Replaced burned out motor, replaced bearings. Time required 32 man-hours.

14. Shafting:

(a) Four key failures due to overtravel of control drive on the original three-boiler installation. Overtravel caused by taper pin shearing in control drive.
Remedy: Replacement of keys. Time required 24 man-hours.
(b) Ten taper pin failures in damper couplings. On the latter installation, due to hand closing of damper when boiler is on cold standby. This cannot happen on control from boiler, due to limit cam preventing less clutch coming in at this point. Dampers are set at minimum limit of control ¼ in. open at laps of damper. Damper has five laps on each side of inlet to fan. Due to the great reduction of force by drive, a very small pressure applied to hand-wheel can cause shearing of these pins, if the dampers stick or are in the closed position.
Remedy: Definite instructions to operators in correct procedure for hand closing of dampers. Time required 76 hours.

15. Time limit springs:

(a) Ten failures have occurred from this source.
Remedy: Adjustment of kick-back spring on time limit assembly and new limit springs. Time required 20 hours.

16-17. Miscellaneous equipment failures:

(a) Tapered pins—four failures.
Remedy: High quality steel used by machine shop in making pins. Time required 24 man-hours.

18. Push button stations:

(a) One failure after approximately 2½ years' service. Riveted pin holding push button assembly sheared.
Remedy: Replaced button with spare. Repaired removed one. Time required 1½ hours.

19. Failures due to small screws, nuts, and cotter pins coming loose have caused nine failures on the original three-boiler installation:

(a) Dog point set screw in collar on travel limit cam shaft. Allowed the cams to slide over enough so that none of the clutches could become engaged.
Remedy: Wired in after tightening. Time required 1 man-hour.
(b) Cap screws holding bendix springs in position loosened up and sheared. Two failures.
Remedy: Hole drilled in hex of cap screw and wire inserted which is wrapped around shaft. Time required 2 man-hours.
(c) Dog point set screws in spur gear on drive shafting in control drive dropped out. Allowed the gears to come off shaft, which put control drive out of service by push button or automatic. Hand control at drive O.K. Three failures at same time.
Remedy: Wired in screws after tightening. Time required 3 man-hours.
(d) Fillister head screws holding sprocket to bevel gear drive shaft. Two failures due to loosening and shearing. This caused loss of control on forced draft fan speed either by hand or automatic.
Remedy: New Fillister head screws installed and center-punched to prevent working loose. Time required 10 hours.
(e) When change over was made on the three original boilers to double speed control, all other loose parts and pieces subject to coming loose were locked by washers or wires. The later drives received, came with this feature included.
Time required 22 hours.

20. Suggestions and changes:

(a) Dividing top of drives and hinging same to facilitate work and inspection.
(b) Fuel drive location gives greater accessibility to parts for repairs and inspection.
(c) Mercoid cam shaft milled with small teeth gives a positive setting against the old method of using headless set screws.

The repair work enumerated above totals 594 man-hours on approximately 60,000 boiler-hours. This means that, beside inspection and overhaul, one hour's repair work is required for every 100 boiler operating-hours.

## *Statement of Pacific Gas and Electric Company*

STATION C, OAKLAND

*$CO_2$ Recorders—*

1. Flue gas is passed through a calcium chloride dryer. The purchaser found it advisable to add a sulphuric acid dryer further to dry the flue gas. The flue gas is not passed through a water cooler.

2. Calcium chloride in small crystals cemented together in the dryer and stopped the flow of flue gas. Very large crystals are satisfactory.

3. The parts containing flue gas must be carefully inspected for air leaks even when first received from the manufacturer.

4. The time lag between changing the setting of the fuel gas valve or damper and the indication on the recorder is two or three minutes.

5. The instrument registers correctly as checked by an Orsat to within the limits required by good firing practice. This degree of accuracy is maintained over long periods of operation without an undue amount of attention or expense.

6. The presence of CO gas is indicated by a large drop in the record of $CO_2$. The operator who is handling the fuel gas and dampers has no difficulty in distinguishing between CO and large excess air.

7. Greasing of the bearings of the small motor which drives the recorder must be done with great care. If grease is allowed to get on the contacts, etc., serious damage to the recorder may result.

*Combustion Control—*

8. This control is applied to two large boilers serving a unit of 40,000-kw. to 45,000-kw. capacity. There are twenty gas burners in each boiler.

9. With both boilers on the line, it is necessary to reduce the number of burners in service when the load is 20,000 kw. and less. Therefore neither the full nor semi-automatic control is used below this point. The control is by push button guided by boiler meters and $CO_2$ recorders.

10. When carrying a fairly steady 20,000-kw. load, one boiler is put on full automatic control.

11. Semi-automatic control means that both boilers are completely controlled by one push button station. This control is used for loads of more than 20,000 kw., when the load is fluctuating. Under this condition the full automatic causes undue fluctuations in the fuel gas flow, by reason of which the gas metering charts are difficult to interpret and the results are inaccurate.

12. The full automatic is used for fairly steady loads over 20,000 kw. Under this condition the operation of the control leaves nothing to be desired.

13. When a considerable change in load is to be made in a fairly gradual manner, the full automatic is used to bring about the change. It is then cut out or not, depending on conditions as noted above.

14. Data of service hours under the different conditions is not available. The station operates under all conditions from 3,000-kw. standby to full block load. It is estimated that the control is used about as follows:

Push button—50 per cent.
Semi-automatic—47 per cent.
Full automatic—3 per cent.

STATION A, SAN FRANCISCO

*Boiler Meters—*

1. There are two boilers, each of 22,250 sq.ft. Each boiler is fitted with a boiler meter and a set of draft gages. The boilers are gas fired with twenty burners each.

2. All instruments are protected from excess vacuum by mercury seals. This we regard as important.

3. The instruments were adjusted by the manufacturer when the plant was started in January, 1930, and again when the fuel was changed from oil to gas in July, 1930, Other than this the instruments have required no maintenance or adjustment.

4. The draft in the furnace is automatically regulated to minus 0.2 in. of water. The induced draft damper and gas valves are hand regulated through independent push button stations.

5. The men must understand the limitations of the boiler meter, especially when firing gas. A sudden change in load or any change that temporarily upsets the steam-air ratio renders the meters useless for the time being. The men soon learn the relation between the gas pressure and draft as indicated by the draft and gas gages and are guided by them until conditions become normal.

6. When sufficient air is used for combustion, the electric type $CO_2$ recorder shows a correct $CO_2$. In case of too little air the deficiency is shown by a decided apparent drop in the recorded $CO_2$ as shown by the meter. In practice this corresponds to the same results as shown on the boiler meter.

*$CO_2$ Recorders—*

7. Two $CO_2$ and CO recorders have been in operation for about two months.

8. They were set up and operated exactly in accordance with instructions furnished by the manufacturer. It is required daily that needle of $CO_2$ tester be set to red mark, and manometer adjusted to show 1 in. suction. It is required weekly that gas line and orifice be tested for clogging, and tester be balanced on air.

9. Other than meeting such requirements as the above and changing charts, the machines have required no attention. The accuracy of the $CO_2$ record is plus or minus ¼ per cent of $CO_2$ compared with the Orsat. The accuracy of the CO record has not been tested.

10. The time lag between changing the setting of the fuel gas valve or damper and the record is about two minutes and seems to be the same at all loads.

## *Operating and Maintenance Practice**

*This report includes (1) a brief description of the erating Code Manual No. 289-58. It supplements this code with certain rules especially applying to oil and gas fired boilers.*

A RECOMMENDATION was made last April at Fresno by the subcommittee on review and was approved by the members there present, that this committee on operation and maintenance practice prepare an operating code to serve as a supplement to the National Electric Light Association Serial Report No. 289-58, dated May, 1929, with particular reference to the operation of oil and gas-fired boilers. After a careful study of the above mentioned manual, it is the opinion of this committee that it is practically impossible to draft any code that is applicable to the operation of all plants. In fact, we believe that every operating company finds it necessary to make changes in its operating rules from time to time. Any company desiring to formulate a code for its plant will find plenty of material to select from in Operating Code Manual No. 289-58, excepting that applying to oil and gas firing.

Since all rules are intended for the proper and safe operation of equipment as well as for the safety of the men in attendance, the first rule should be intelligence, properly applied, or what is more specifically known as common sense.

The following rules on gas and oil-fired boilers are for the purpose of supplementing those given in the manual for stoker and pulverized fuel-fired boilers.

PUTTING BOILER ON THE LINE—GAS OR OIL FIRED

1. Proceed according to 102-S, Rules 1-9, inclusive, Operating Code Manual No. 289-58. Note:

*For Oil Firing*—See that —— lb. oil pressure are on burner lines. Open bypass at boiler, allowing oil to circulate to remove cold oil from burner lines. When temperature of oil has reached —— deg. F. you are ready to start fires.

*For Gas Firing*—First assure yourself that you have —— lb. pressure on burner header. You are then ready to start fires.

2. General instructions for lighting either gas or oil fires:

(*a*) Before lighting either gas or oil, assure yourself that all oil or gas valves are closed and that there has been no leakage of fuel into the furnace.

(*b*) Open damper wide for not less than three minutes. This is for the purpose of purging the boiler and setting off any combustible gases that may have accumulated due to leakage past valves.

(*c*) Set damper back far enough to prevent draft from extinguishing torch. Apply torch to one of the burners, opening gas valve rapidly at the same time. (Torches must be in a condition that insures their giving a large and effective flame.)

(*d*) If your torch goes out or you experience any difficulty in starting fire, shut off gas and open damper wide. Then start proceedings anew.

(*e*) Do not attempt to light one burner from another in a cold furnace.

(*f*) Keep a close watch on your burners after they have been ignited. There is a possibility of air pockets in the line extinguishing the fire. Take no chances.

3. From here proceed according to 102-S, Rules 18-21, inclusive, 23-31, inclusive, and rules 34 and 35.

* Report of the subcommittee on operation and maintenance practice, prime movers committee, Engineering Section. F. G. Knight, chairman, L. D. Burlingame, W. N. Munro, E. D. Sherwin, H. T. Shirley, W. H. Short, F. B. Stillwagon.

## *Heat Balance, Design and Plant Betterment**

*This report includes (1) a brief description of the principal features of Pacific Coast plants now under construction, and (2) a discussion of the method of ob-*

* Report of the subcommittee on heat balance, design and plant betterment, prime movers committee, Engineering Section. V. F. Estcourt, chairman. L. A. Hicks, Leo J. Kraps, J. S. Moulton, M. E. Mulkey.

*taining boiler efficiency by heat balance calculations. Results from actual tests are given, showing the comparison between this method and the weighed or metered fuel and water method. A set of curves for making quick calculations of boiler efficiency by the heat balance method is also included.*

### New Pacific Coast Installations

IT WAS the original intention of this subcommittee to follow up the previous year's work by compiling actual operating data showing the comparative performance at full and partial loads of Pacific Coast stations operating under various cycles and pressures. A considerable amount of data was actually collected, but this subcommittee feels that the whole range of pressure from 200 lb. to 1,400 lb. should be covered in order to make the report of the greatest possible value. It has therefore been felt best to postpone a report on this subject until next year so that figures may be included in

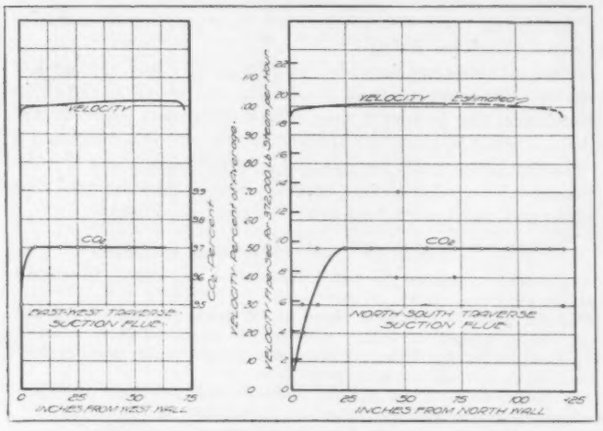


*Fig. 1. Velocity and $CO_2$ traverse made at suction of induced draft fan, (gas fuel). Boiler No. 50, Long Beach steam station.*

connection with the 1,400-lb. units of the Pacific Gas and Electric Company's Station A, the only installation on the Pacific Coast now operating at this pressure.

In addition to the two 1,400-lb. units for Station A, briefly described in last year's report, one of which is now in operation, another unit for the same pressure is now contemplated by the Pacific Gas and Electric Company and is in the preliminary stages of design. The plant will be located near Fresno and will consist of one 50,000-kw. compound turbo-

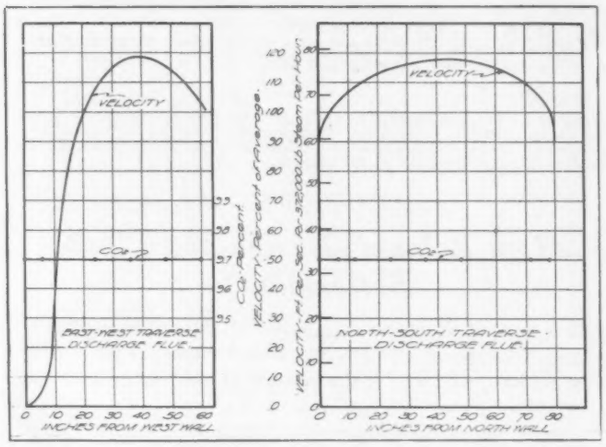


*Fig. 2. Velocity and $CO_2$ traverse made at discharge of induced draft fan, (gas fuel). Boiler No. 50, Long Beach steam station.*

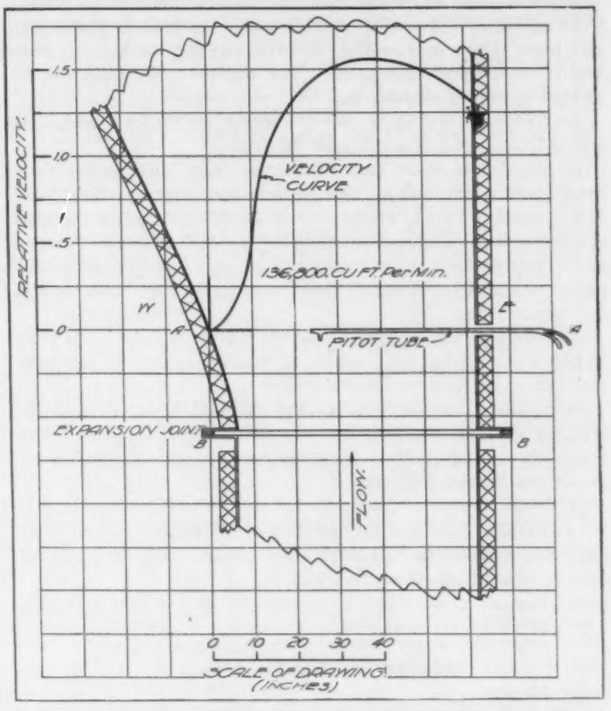


*Fig. 3. Section through discharge flue, showing location of pilot tube for velocity traverse (gas fuel). Boiler No. 50, Long Beach steam station.*

generator (65,000 kw. maximum) and one boiler of the reheat type rated at 575,000 lb. per hour maximum. The steam temperature will be 825 deg. F. at the high-pressure turbine throttle with reheating to the same temperature for the low-pressure turbine. Auxiliaries will all be electrically driven and supplied from a 5,000-kw. condensing house, set also to operate at 1,200-lb. steam pressure. The gain in economy due to the higher steam temperature, that is to say, 825 deg. F. instead of 750 deg. F., is estimated at about 3 per cent, although the actual over-all economy will probably

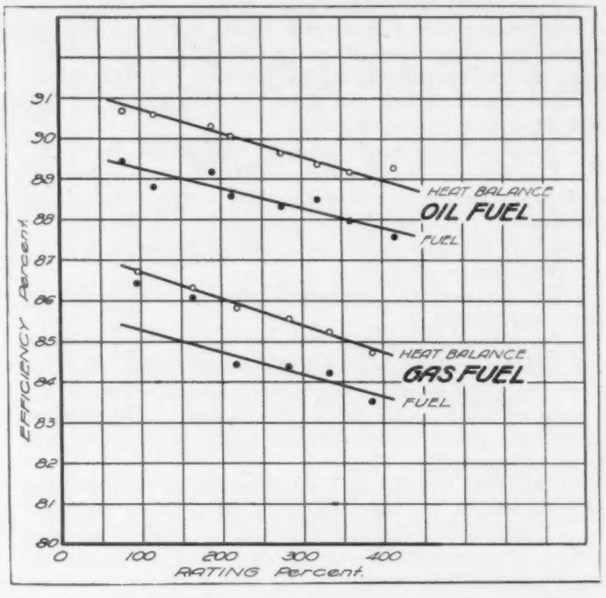


*Fig. 4. Comparison of boiler efficiencies calculated by heat balance method and weighed or metered fuel and water method. Efficiencies based on boiler superheater water walls and air heater. From tests on boiler No. 50, Long Beach steam station.*

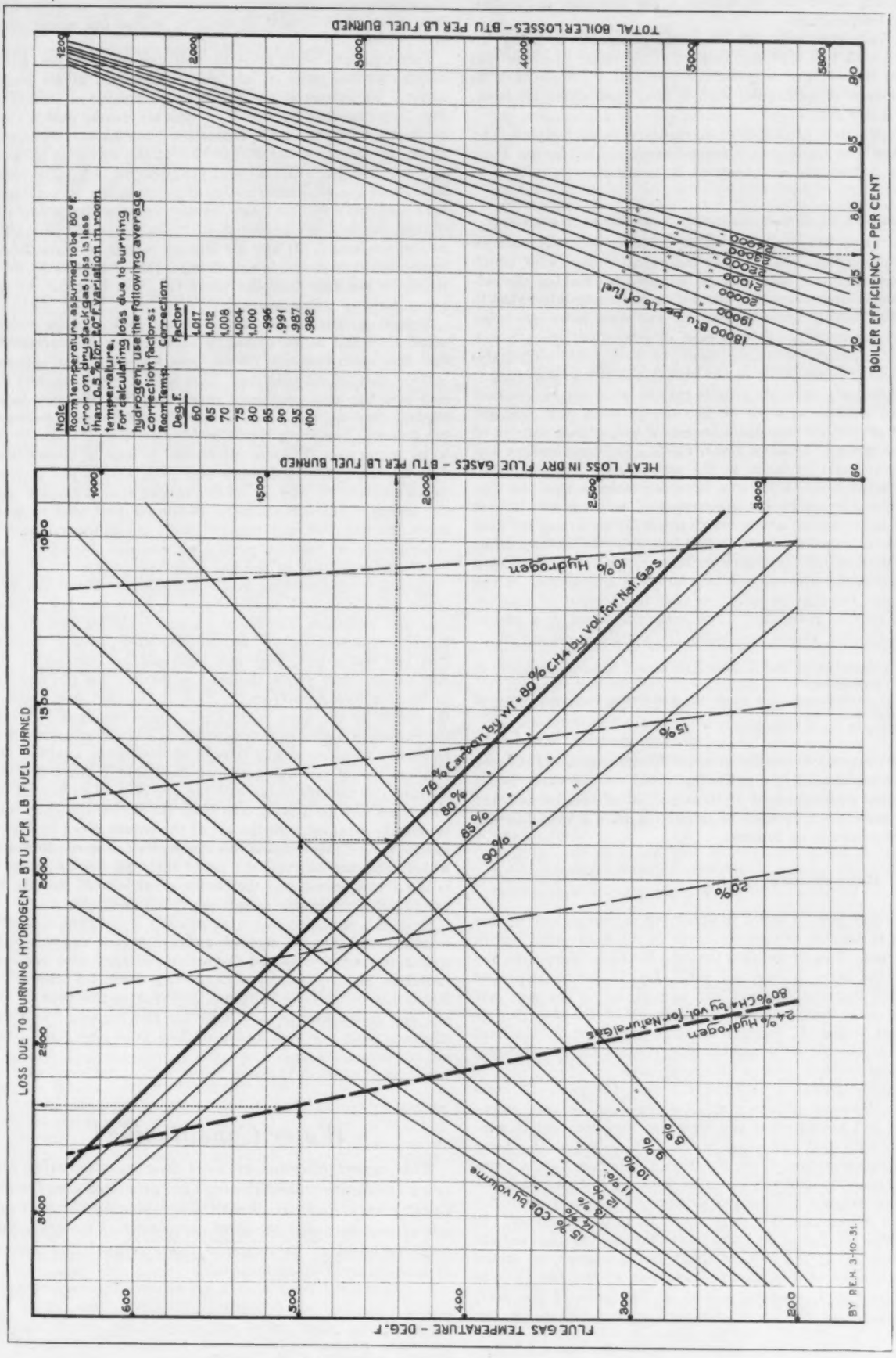


*Fig. 5. Curves for obtaining boiler efficiency by heat balance method.*

not be any better than at Station A, due to higher circulating water temperatures.

At Pasadena, a 25,000-kw. turbo-generator is being installed with two 1,500-hp. boilers. The steam pressure will be 400 lb. and the temperature 750 deg. F.; there will be four stages of extraction with a final feed water temperature of 390 deg. F.

A third unit of 100,000-kw. capacity is contemplated by the Southern California Edison Company Ltd. for its Long Beach station, the arrangement to be similar to units Nos. 10 and 11.

### Obtaining Boiler Efficiency by Heat Balance

The value of obtaining boiler efficiency by heat balance calculations lies chiefly in the comparative ease with which the necessary test data may be obtained for making the calculations. Moreover, this method is pecularly adaptable to Pacific Coast practice where oil and gas fuels are used almost exclusively. In the case of coal fuel, there are a greater number of losses hard to determine accurately, such as the combustible in the refuse and in the flue dust.

Surprisingly accurate results may be obtained by the heat balance method with oil or gas firing, when exit flue gas temperatures are measured correctly and a true sample of the flue gases is obtained for analysis. The temperature and analysis should be taken at the same place. Even the best constructed boiler will have some air leakage into the system; for this reason the proportion of excess air is largest at the boiler outlet, and it would evidently be wrong for heat balance calculations to take flue gas analyses at any other place than at the air heater outlet. All that it is necessary to know is the amount, temperature and composition of the flue gases leaving the boiler, sq that the amount of heat rejected may be calculated. The principal losses in a gas or oil-fired boiler where combustion is complete, consist of:

1. The loss due to the sensible heat above room temperature in the dry flue gases.
2. The loss due to the steam formed from the combustion of hydrogen in the fuel.
3. The loss due to radiation.

Other losses are usually very small and only a slight error will be introduced by neglecting them. If the three losses mentioned are expressed in B.t.u. per lb. of fuel burned, the boiler efficiency may then be calculated with a very fair degree of accuracy as follows:

$$\text{Boiler efficiency} = \frac{100\ (\text{Item 1} + \text{Item 2} + \text{Item 3})}{\text{Bt.u. per lb. of fuel}}$$

If proper care is taken in obtaining a true sample of flue gas, it is possible to keep the error in the final result within 1 per cent. Due to the fact that the losses in themselves are small, the error in the per cent of $CO_2$ due to improper sampling and analysis may run as high as 0.5 per cent and the error in temperature measurement of the flue gas as high as 15 deg. F. without bringing the error in the final result above the value mentioned. The matter of obtaining the radiation loss will be discussed later.

*Tests by Southern California Edison Company*—A comparison between efficiency obtained by heat balance calculations and by metering and weighing was obtained in connection with test run on a 34,162-sq.ft. boiler at the Long Beach steam station of the Southern California Edison Company Ltd. The boiler was tested with oil and gas fuel, the oil being weighed and the gas metered by means of an orifice meter. All precautions were taken to insure accuracy. It was definitely proved by these tests that the flue gas analysis was uniform at the induced draft fan discharge, as shown by the curves of Fig. 2. The analysis at the fan inlet is given in Fig. 1, showing a drop at the walls of the duct. The reason for the large variations in velocity at the fan discharge is evident from the shape of the duct as shown in Fig. 3, but it is clear that this variation does not affect the accuracy of the results, because the $CO_2$ content of the flue gases at this point is uniform across the whole width of the duct.

Investigations were also made of the temperature distributions of flue gases at air heater inlet and at air heater outlet. Variations at the boiler outlet amounted to only 16 deg. F. as against 50 deg. F. at the air heater outlet. The air leakage increased the excess air from about 15 per cent at the furnace to about 22 per cent at the stack. Theoretically the flue gas analyses and temperature should be taken as close to the air heater outlet as possible, but it is actually very desirable to take them at the induced draft fan discharge due to the elimination of stratification at this point as just explained. If any air leakage occurs between the air heater outlet and the fan discharge, the error will be minimized by the fact that the lower $CO_2$ will be offset by the lower flue gas temperature.

Referring now to the curves shown in Fig. 4, it will be noted that the boiler efficiency obtained by measuring the fuel was approximately 1.3 per cent less than that obtained by heat balance calculations. This holds for both oil and gas fuel over the whole range of capacities, the difference being slightly less at high capacities. This difference indicates the losses by radiation, which will decrease as the size of the boiler increases. It is also interesting to note on these curves that the theoretical difference of a little over 4 per cent between gas and oil fuel efficiencies checks almost exactly with the actual difference shown. As the oil fuel was weighed while the gas fuel was metered with an orifice meter, this close agreement between results with oil and gas fuel establishes the reliability of the gas metering system.

*Curves for Calculating Boiler Efficiencies*—From the foregoing discussion and description of tests it has been shown that the radiation loss for a particular boiler may be obtained by comparing the result calculated from a weighed fuel and water test, with that obtained by subtracting the sum of the losses due to the heat in the dry flue gas and due to burning hydrogen from the heat in the fuel, and dividing the result by the heat in the fuel. Once having determined the radiation losses in this manner, the boiler efficiency may be readily obtained at any time by obtaining the analyses and temperature of the flue gases at the induced draft fan discharge; the calorific value and the per cent of carbon in the fuel must also be known, and then the boiler efficiency may be quickly obtained with the aid of the curves given in Fig. 5. These curves were made up from well known formulas which need not be repeated here; their particular value is in the arrangement, and they cover a range wide enough for use in connection with either gas or oil fuel.

Since the radiation loss is practically a constant quantity, excellent comparative figures under different conditions of operation may be obtained for boiler efficiency plus per cent radiation loss by merely determining from the curve the losses due to burning hydrogen and due to the heat in the dry flue gases, adding them together and reading the boiler efficiency plus per cent radiation loss from the right hand set of curves.

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## *Water Conditioning**

*This report contains answers to a questionnaire covering feedwater conditioning as practiced in Pacific Coast plants, and curves and data showing the percentage of moisture and the total carry-over of moisture and solid material to be expected from present day boilers of larger size.*

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* Report of the subcommittee on water conditioning, prime movers committee, Engineering Section. M. E. Mulkey, chairman. A. J. Meudell, A. Sattler, C. W. Wiggins.

THIS committee has investigated the subject of feed water conditioning as practiced in Pacific Coast plants, in search of new developments since last year's report, but nothing new in the control of boiler water is reported.

The following questionnaire was sent to each member company:

1. Is make-up from evaporators or direct from treating plant?
2. Is phosphate used alone for treatment?
3. If so, do you use mono, di, tri, or Hagan phosphate?
4. If phosphate is used alone, how is it prepared, and at what point in the system is it introduced, and how introduced?
5. What phenolphthalein and methyl orange alkalinities do you aim to carry? How much free $PO_4$? Do you have trouble in maintaining these at desired amount due to fluctuating load, or due to condenser leakage?
6. What hydrate alkalinity, as NaOH, do you aim to maintain?
7. Do you use other chemicals in conjunction with phosphate?
8. Do you have carry-over?
9. Do you draw a continuous sample from the steam header and use recording instruments to show when boilers are sending over wet steam?
10. What is the upper limit of total solids in your boiler water?
11. Do you have any deposit on turbine blading?
12. Are drums and tubes smooth and clean when you open your boilers, or are they coated with red deposit?
13. Are feed water lines clean and bright, or is there a residue?
14. Do you circulate any boiler water through the feed water lines to maintain alkalinity in the feed lines?

### Statement of the San Diego Consolidated Gas & Electric Company

In our old Station A, which is a small plant of 10,000 kw., and used only in cases of emergency and for supplying steam to the adjoining gas plant and some steam consumers near by, the operating pressure is 160 lb. In this plant we use Dearborn boiler compound. The make-up water is taken from the city water system.

In our Station B, 64,000-kw. rated capacity, the operating pressure is 250 lb. Make-up water is city water and it is all softened by passing through Permutit zeolite softeners. We have no evaporators. Water from stage heaters at about 160 deg. F. and softened make-up water is heated to 212 deg. F. and deaerated in open feed water heaters. From the open feed water heaters the feed water is pumped through high-pressure heaters to the boilers at about 260 deg. F.

The following answers to the questionnaire apply to Station B:

1. Make-up water is taken from tanks, which are supplied by softened water from continous blow-down heat exchangers.

2, 3, 4. We do not use phosphate.

5. No alkalinity control is used. Concentration is determined and controlled by determination of chlorides. No particular trouble is experienced in maintaining desired total solids concentration, as indicated by chlorides as worked out by continuous blow-down from boiler drums and interval blow-down of water walls and mud drums.

6. Hydrate is not regulated, other than as explained in answer number five. OH and NaOH varies from 150 to 700 parts per million. Carbonate varies from 100 to 400 parts per million.

7. No phosphate is used. Sodium sulphate is used to maintain a ratio of 2.5 sodium carbonate plus sodium sulphate divided by sodium hydroxide. The sodium sulphate is fed into the make-up water tanks.

8. We do not have carry-over, although we operate boilers up to 360 per cent of rating.

9. We do not draw a continuous sample from the steam header and do not use recording instruments to show when boilers are sending over wet steam.

10. With control of chlorides set at 1,300 parts per million, as sodium chloride, the total solids are maintained at about 6,000 parts per million.

11. We do not have any deposit on turbine blading.

12. Boiler drums are quite clean, with a very light coating of a red deposit. We usually wire brush the surfaces and paint with Apexior when the boilers are given a general overhauling.

13. We find considerable corrosion in the feed water lines.

14. We do not circulate any boiler water through the feed water lines to maintain alkalinity in them.

### Statement of Southern California Edison Company Ltd.

Since the last report there has been no change made during the year in the treatment or conditioning of boiler water at the Long Beach plant.

The following are answers to the questionnaire:

1. Make-up is from evaporators.

2. We use sulphate in addition to phosphate.

3. We use tri-sodium phosphate.

4. All chemicals added to the boiler water are pumped into the individual boiler through the boiler feed lines.

5. (*a*) We carry methyl orange alkalinity calculated as sodium carbonate above 70 parts per million, or 4 grains per gallon, and the (*b*) phenolphthalein alkalinity above 34 parts per million, or 2 grains per gallon in terms of sodium hydrate. (*c*) $PO_4$ phosphate is kept around 68 parts per million or 4 grains per gallon. (*d*) When there is little condenser leakage as shown by our Unit 10 and Unit 11, there is little trouble maintaining the desired amount, but there is considerable trouble when there is condenser leakage as occurs in Unit 8 and Unit 9.

6. We maintain OH as NaOH above 34 parts per million.

7. We use sulphate and caustic soda in conjunction with tri-sodium phosphate.

8. We have about 0.25 per cent carry-over at 325 per cent of rating.

9. We do not draw a continuous sample.

10. The upper limits of total solids in boiler water is 1,700 parts per million.

11. We do have some deposit on turbine blading.

12. Our drums and tubes are smooth and clean when boilers are opened. No red deposit or coating.

13. Feed water lines are clean.

14. We do not circulate boiler water through the feed water lines to maintain alkalinity in the feed lines.

*Influence of Boiler Rating on Carry-over of Solids*—The usual method of expressing the carry-over from a boiler drum is by stating the quality of, or the per cent moisture contained in, the steam delivered from the saturated drum.

The per cent of moisture carried with the steam in a given boiler is influenced by the height of water in the drum, the kind and concentration of solids contained in the boiler, and the rate of steam liberation.

In well designed water tube boilers the per cent of moisture carried with the steam may vary from 0.05 per cent at 100 per cent rating to around 0.6 per cent at 400 per cent rating under good operating conditions, an increase of about twelve fold.

These values do not give a very clear presentation of the actual amount of water being carried over, since the boiler output is also increasing. To arrive at a figure representing pounds of moisture per hour entrained with the steam, it is necessary to multiply the per cent moisture by the output in pounds divided by 100.

After this figure is obtained it can be multiplied by suitable factors for the boiler water concentration to give the total pounds of solids per hour or per day carried over with the steam.

The curves shown in Fig. 1 give a good example of this. The per cent moisture between 100 per cent and 400 per cent rating varies from about 0.05 per cent to 0.6 per cent, an increase of twelve times. At the same time the steam output from the boiler increases approximately four times.

Therefore, the total moisture carry-over from the boiler in pounds has increased 4 times 12, or 48 times. Assuming a constant concentration in the water in the boiler drum, the total solids carried over have also increased 48 times, or in the case shown, where a concentration of 1,000 parts per million is assumed, the pounds per day of solids carried over per boiler operating at 100 per cent rating would be approximately 1¾ lb. per day, and at 400 per cent rating it would be about 70 lb. per day.

This has a very marked effect on the rate of deposits on turbine blading and superheater tubes when high ratings are maintained over considerable periods of time.

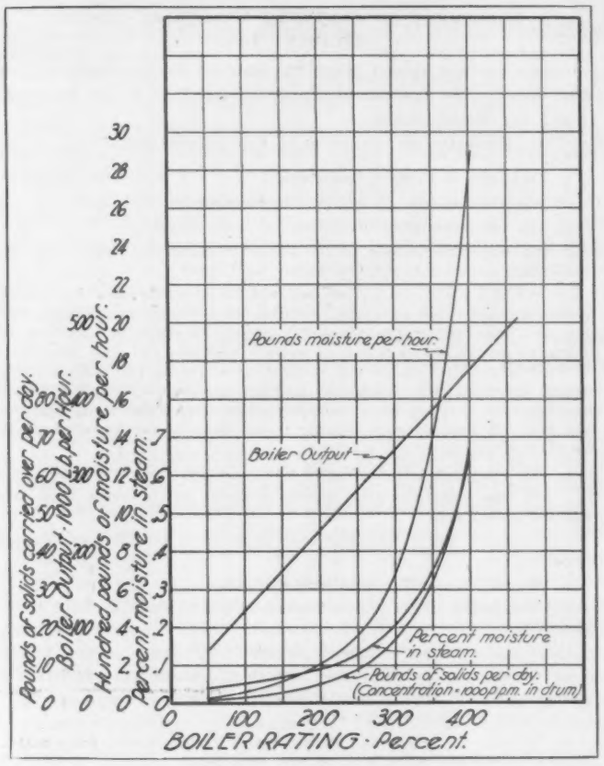

Pounds moisture per hour.
Boiler Output
Percent moisture in steam.
Pounds of solids per day. (Concentration · 1000 p.p.m. in drum)
Pounds of solids carried over per day.
Boiler Output · 1000 lbs. per hour.
Hundred pounds of moisture per hour.
Percent moisture in steam.
BOILER RATING · Percent.

*Fig. 1. Curves showing moisture in steam and amount of solid matter carried over at various boiler ratings.*

### Statement of Los Angeles Gas and Electric Corporation

**Following are answers to the questionnaire:**

1. Make-up is from evaporators at both the Seal Beach and Alameda Street plants.
2, 3. No phosphate used.
4. Chemicals are pumped directly to boilers.
5. We pay no attention to alkalinities as such, but maintain definite ratios between sulphates, calculated as sodium sulphate, and total alkilinity, calculated as sodium carbonate. At the Alameda Street station the ratios vary from 3 to 1 to 5 to 1. At Seal Beach the ratio varies from 6 to 1 to 12 to 1.
6. Hydrate not taken into consideration as NaOH.
7. No phosphate used. Sulphate is used.
8. No carry-over.
9. Do not draw a continuous sample from the steam header.
10. The maximum total solids allowed at the Alameda plant is 200 grains per gallon. At the Seal Beach plant, 100 grains per gallon.
11. No deposit on turbine blading.
12. Boiler drums and tubes are smooth and clean.
13. Feed lines are clean.
14. Do not circulate any boiler water through feed water lines to maintain alkalinity.

### Statement of Pacific Gas and Electric Company

**There has been no change in boiler feed water conditioning since last year's report. The following answers to the questionnaire apply to Station C, Oakland, 450-lb. pressure boilers:**

1. Make-up water is from evaporators, the evaporator feed having been previously treated in hot process lime-soda softener.
2. Phosphate is the only conditioning chemical used.
3. We use commercial tri-sodium phosphate.
4. The phosphate crystals are dissolved in hot water and pumped into the condensate line at the drip pump's discharge. The phosphate is pumped into the line with a hand pump and in small quantities, about two gallons at a time at about 15-minute intervals. Phosphate is added as required, as shown by tests on the boiler water.
5. (*a*) We carry methyl orange alkalinity calculated as sodium carbonate around 25 to 30 parts per million, and (*b*) phenolphthalein alkalinity about 16 parts per million in terms of sodium hydrate. (*c*) Phosphate is kept around 35 or 40 parts per million. (*d*) When the condenser is tight, or has only a slight leakage, there is no difficulty in maintaining free $PO_4$, but with condenser leakage of any appreciable amount, it is quite difficult to maintain the desired amount of $PO_4$.
6. We maintain OH as NaOH around 16 parts per million. However, when using tri-sodium phosphate alone, the hydrate varies considerably with the rating at which the boiler is operating.
7. We use no other chemicals in conjunction with phosphate.
8. In two years' operation we have not noted any carry-over.
9. We draw a continuous sample from the superheater inlet and use a Leeds & Northrup salinity recorder to show if there are impurities in the steam.
10. Our upper limit of total solids in the boiler water is 1,000 parts per million.
11. At the last inspection, after eighteen months of operation, there was no deposit on turbine blading.
12. The drums and tubes are free from scale, but there has always been a thin coating of red dust in the boiler tubes and in the drums below the water line.
13. There is a thin coating of soft residue in the feed water lines.
14. We do not circulate boiler water through the feed water lines to maintain alkalinity.

# UNDERGROUND SYSTEMS COMMITTEE REPORTS[1]

## *Progress in the Application and Use of the Low Voltage A.C. Network System**

*This report is intended to cover only the systems of the member companies of the Pacific Coast Electrical Association, the broader aspects of the application and use of the a.c. network systems being contained in the reports of the underground systems committee of the national association. Previous reports of the automatic a.c. network systems committee of both the Pacific Coast section and the national section having given data*

* Report of subcommittee on progress in the economic application and use of the low voltage a.c. network system, undergound systems committee, Engineering Section. J. F. Hodges, chairman. M. N. Clark, C. V. Fairchild, D. J. Kelly, C. G. Mansfield, G. P. Mackenzie, P. J. Ost, A. C. Putnam, G. A. Riley, R. J. Smith, Paul Suransky.

[1] E. R. Stauffacher, Southern California Edison Company Ltd., chairman. J. C. McClung, Los Angeles Gas and Electric Corporation, vice-chairman.
American Steel & Wire Company: H. N. Pratt.
Copperweld Steel Company: C. E. Ingalls.
General Cable Corporation: O. R. Grant, W. G. Stearns.
General Electric Company: W. C. North, G. P. Mackenzie.
Glendale Public Service Department: R. C. Smith.
Kerite Insulated Cable Company: J. P. Robinson.
Los Angeles Bureau of Power & Light; C. H. Jenkins, C. G. Mansfield.
Los Angeles Gas and Electric Corporation: P. F. Meinick, E. R. Northmore, Z. T. Pettit, G. A. Riley.
Okanite Cable Company: T. T. Kennedy.
Pacific Gas and Electric Company: E. M. Beal, Geo. Brand, H. H. Buell, P. E. Chapman, M. N. Clark, R. R. Cowles, W. K. Cullen, G. H. Hagar, G. L. Hill, H. G. Keesling, R. P. Lutzi, H. C. Moyer, Paul Suransky.
Safety Cable Company: J. E. Crilly.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, D. J. Kelly.
San Francisco Engineering Department: P. J. Ost.
San Joaquin Light & Power Corporation: H. H. Minor.
Southern California Edison Company Ltd.: C. E. Biggs, W. C. Curl, C. V. Fairchild, N. B. Hinson, J. F. Hodges.
The Southern Sierras Power Company: A. C. Putnam.
Standard Underground Cable Company: Vinton Smith.
Westinghouse Electric & Manufacturing Company: D. C. Harker, C. C. Potts.

*upon the various schemes of connection and operation, it is not intended in this report to cover the characteristics of the apparatus nor the operating performance in detail, but to confine the report on the economic features as applied to those studies either completed or undergoing consideration and some of the problems encountered in the consideration before adoption.*

THE growth of the low voltage a.c. network system, as shown by the national report of 1930, has been very rapid during the past few years. This system of distribution is defined as one in which the secondary is so interconnected as to form a solid network, with its supply from several transformers connected to two or more feeders. The secondary system is designed to clear itself of secondary faults and the primary feeders and transformers are so protected as to be isolated from the system in case of trouble, without an interruption to the secondary service.

The preference for this system has grown, due to its reliability of service and ease of expansion and its economic advisability in congested business sections of cities. Its installation, therefore, depends upon the load density, service requirements, physical possibility and economical advisability.

Reports from various member companies indicate a decided interest in the a.c. network system. The Pacific Gas and Electric Company of San Francisco had had a small area in satisfactory operation for the past year, as reported by P. E. Chapman in 1930. With the exception of the Southern California Edison Company Ltd., and the above mentioned company, none of the other members have made more than a cursory investigation of the economical advisability of such a system.

The following is the economic study made at Long Beach on the Southern California Edison Company Ltd. system.

## Reason for Study

The city of Long Beach has grown very rapidly, especially during the past ten years. This growth has been not only in population but in business and industry. The rapid increase in retail business and the construction of large office, theatre and apartment buildings indicated that a very highly concentrated load might be expected in the downtown area and along the ocean front.

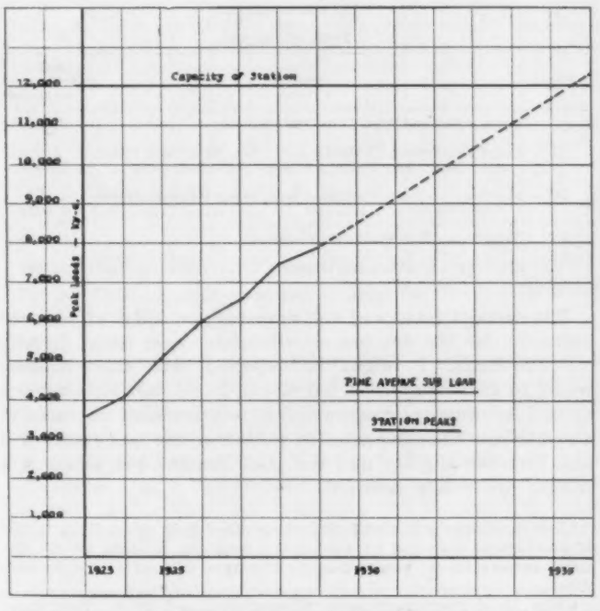



*Fig. 1. A straight line projection of Pine Avenue substation peak demands shows that the capacity of the station will be reached in five years.*

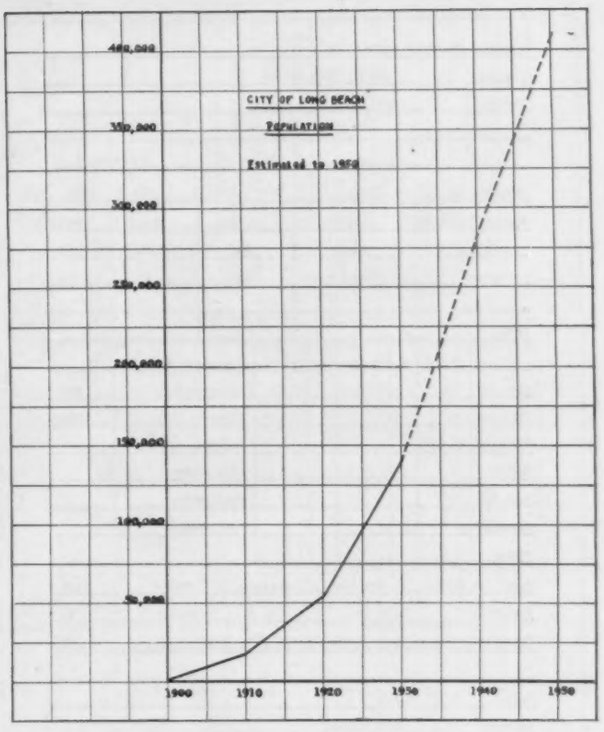



*Fig. 2. Estimate of population of the city of Long Beach for the next twenty years.*

At the present time the entire underground distribution system in the downtown section is fed from one substation only—with ties, of course, to overhead circuits from other sources. This station, Pine Avenue, is on a small lot in the very heart of the retail business district and there is no possibility of further expansion at this location. A straight line projection of the peak demands, as shown in Fig. 1, shows that the ultimate capacity will be reached in approximately five years. This would make it necessary to build one, and possibly two, new substations very shortly unless some other method of handling the load could be developed.

## Population Growth

The estimate of the population for the next twenty years (Fig. 2) shows a considerably greater rate of growth than was experienced during the past ten years. Practically all other indices of growth also show a similar trend. A study of building permits showed a very definite change in housing conditions from single family residences and flats to large apartment houses and hotels. Practically all of the large apartment buildings have been built and probably will be built in the future, within the so-called downtown area.

## Consideration of Assessed Valuation as an Index

Assessed valuation is quite generally used as an index to growth. At the time the figures were being obtained at the city assessor's office, the method of fixing these values was studied. (Fig. 3 is a sample of the sheet used by the deputy assessors in the field.) It was noted that the grade of construction, the interior finish, the refinements and the conveniences were all considered. It was readily seen that the value placed on the building by the assessor was in some measure dependent on the comfort and convenience desired by the owner. This led to the decision to investigate assessed valuation of buildings as an index to the demand for electric energy.

BUILDING VALUATION SHEET P.D. M.D.

Address: 1234 W. Fifth Street

Tract: Hart

Lot No. 42 Block No. 4

Examined by: A. B. Jones Date: 10/1/29 Built: 1928

| Kind of Building | Exterior | Cu. Ft. Sq. Ft. | Base Price | Total |
|---|---|---|---|---|
| Dwelling | Stucco | 984 | 1.80 | 1771 |
| Garage | Side B & B | 360 | .60 | 216 |

Bsmt.

| | 1 | 2 | 3 | 4 | Rm. Fl. | Rm. Fin | Tile Fin | Com Fl. | Addl. Cost Items | |
|---|---|---|---|---|---|---|---|---|---|---|
| Liv. Rm. | 1 | | | | 1 | | | | Interior Fin. | 136 |
| Din. Rm. | 1 | | | | 1 | | | | Plmbg-No. Fixt. 5 | 200 |
| Bkfst. Rm | | | | | | | | | Lighting | 90 |
| Bed Rm. | 2 | | | | 2 | | | | Tile Roof | |
| Bath Rm. | 1 | | | | | | | | Elec. Refr. | |
| Kitchen | 1 | | | | | | | | Elec. Heater | |
| Store | | | | | | | | | | |

Beds Buffet Bk. Case Dressers Cupbds. 119

Furn. Units Water Htr. Fire Pl. Mantle 80

Trim-Cotto Terra Glass Plate Tile Roofing Grill Brick Tile Marble 10

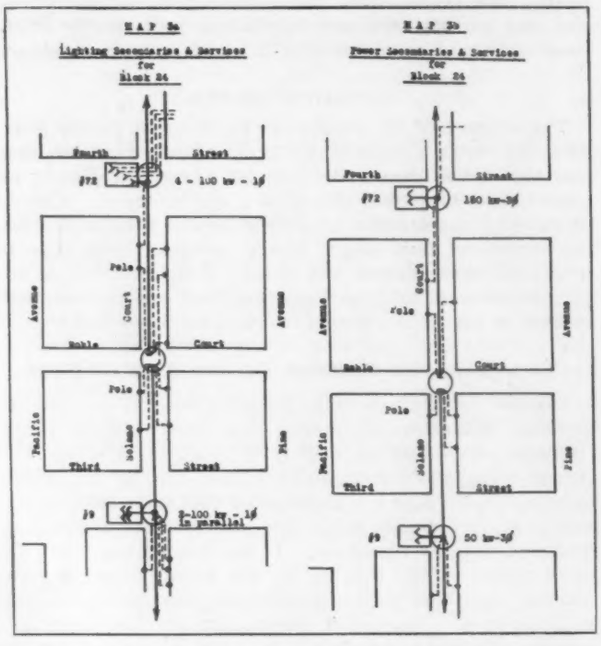
Owner: J. C. Rogers

Address: 1234 W. Fifth Street

| | | | |
|---|---|---|---|
| Permit, Date and Amt: 8/28 - $2780 | Total Cost . . . . . | | 2821 |
| P.C. Total: | Cost, less % Dep. | | |
| P.C. Assessed: | Assessed Value . . . . | | 1310 |

*Fig. 3. Sample of sheet used by deputies in the field.*

Small maps were made showing vaults, manholes, transformers, secondary runs and services for each block in the existing underground area. Separate maps were drawn for the lighting system and the power system (Figs. 4 and 5), the secondary distribution system being six-wire. Using




*Figs. 4 and 5. Separate maps drawn for lighting and power systems.*

these maps in the field, together with a large 100-ft.-to-the-in. map, showing each piece of property, the exact area fed by each transformer vault was determined. Then, from the assessor's records, the assessed value of all buildings fed from each transformer vault was determined.

The peak demand on each vault having already been determined, factors of volt-amperes per dollar of assessed valuation were worked out, and they are strikingly similar for the same character of load, regardless of wide differences in assessed values and demands. Table I shows these assessed values as an index comparison.

**TABLE I**
Assessed Values as an Index Comparisons

| Vault Number | 1929 Assessed Values | Trans. Capacity Kw. | Peak Demand Kva. | Volt-amp. per Dollar |
|---|---|---|---|---|
| A | | | | |
| Piers | $87,675 | 625 | 256 | 2.9199 |
| 234 | 19,465 | 100 | 56 | 2.8770 |
| 53 | 64,185 | 225 | 178 | 2.7732 |
| B | | | | |
| 129 | 207,948 | 150 | 110 | 0.5290 |
| 38 | 200,195 | 150 | 106 | 0.5295 |
| 85 | 438,832 | 375 | 228 | 0.5196 |
| C | | | | |
| 160 | 566,840 | 350 | 207 | 0.3652 |
| 51 | 349,570 | 200 | 116 | 0.3318 |
| Virginia-L. | 78,734 | 50 | 28 | 0.3556 |
| D | | | | |
| 162 | 81,628 | 200 | 67 | 0.8208 |
| 7 | 137,358 | 150 | 108 | 0.7863 |
| 46 | 117,345 | 125 | 100 | 0.8522 |

Group A—These vaults feed the amusement zone.
Group B—Small apartment houses.
Group C—Large apartments and hotels.
Group D—The best class of retail business.

This grouping was not used for predicting future loads but was merely set up to give some idea of the value of the method.

### Use Classifications

From the foregoing it was decided to use the assessed valuation of improvements as an index for future load studies and five "use classifications" and demand factors were developed that would be applicable to the area, as shown in Table II.

**TABLE II**
Use Classifications and Demand Factors

| Class | Use | Demand Volt-amp. per Dollar |
|---|---|---|
| I | Large Retail and High-Class Office Buildings | 0.8554 |
| II | Large Apartments (5 stories and over), First-Class Hotels and Clubs, Large Public and Semi-Public Buildings | 0.3060 |
| III | Multiple Dwellings (4 stories or less), Minor Public and Semi-Public Buildings | 0.4922 |
| IV | Neighborhood or Small Retail Business | 1.0113 |
| V | Single Family Houses and Duplexes | 0.3544 |

The demand factors of volt-amperes per dollar of assessed valuation for the five use classifications were based directly on 1929 loads. It might be expected that these factors would be greater by 1950, but it was found that although the annual kilowatt-hour consumption will probably increase at a faster rate than the assessed valuation, the load factor will also increase slightly and the peak demand per dollar will remain practically constant.

Class I—Large retail and high-class office buildings. This factor of 0.8554 was obtained by taking the weighted average of the demand factors for 24 vaults feeding this type of load at the present time.

Class II—Large apartments (five stories and over), first class hotels and clubs, large public and semi-public buildings. Nine vaults feeding large apartments, hotels and a club were averaged for this figure of 0.3060.

Class III—Multiple dwellings (four stories or less), minor public and semi-public buildings. The factor for this class was slightly higher than for Class II, 0.4922, the diversity being less than in the larger buildings. This was an average of ten vaults.

Class IV—Neighborhood or small retail business. Several vaults, known to feed mostly small stores, were selected and the average of 1.0113 taken for the demand factor. This figure is high because of the cheaper construction of the small buildings rather than because of a large demand for electric energy.

Class V—Single family houses and duplexes. There are no vaults at the present time feeding this class of load. Since these dwellings will be mixed in among both classes of apartment houses, an average factor of 0.3544 was worked out. This figure was based on the average number of families per dwelling and average building costs per family for the past eleven years.

## Application of Demand Factors to Forecast of Assessed Valuation

These factors were applied directly to an estimate of the assessed valuation of each of 235 city blocks for the year 1950. The forecast of population growth, assessed values and like statistical data was not made by the engineers of the Southern California Edison Company Ltd., as a well established statistical engineering firm that had previously made similar studies in the area, was engaged for this purpose. Fig. 6 shows the total assessed valuation of the downtown area. The percentage of assessed valuation in each of the five use classifications was given, so that it was a simple

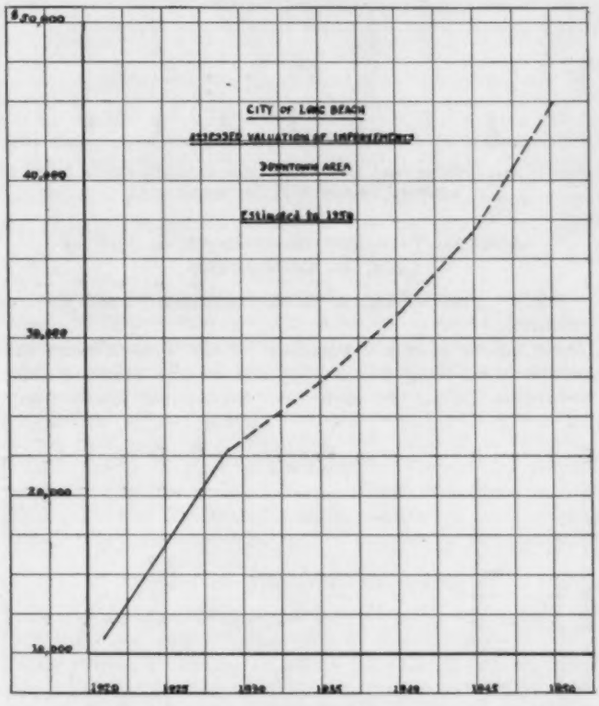



*Fig. 6. Total assessed valuation of downtown area, Long Beach.*

matter to work out the total demand in kva. expected in each block by 1950. Estimates for each block were also furnished for 1935, 1940 and 1945, as well as 1950. The percentage for each of the five use classifications, however, was given for one year only, (1950), as it was desired to figure economies over a twenty-year period. Fig. 7 shows the loads in each of the blocks as computed from the demand factors per each classification and the estimated percentage of each in the 235 blocks.

## Distribution Systems Under Consideration

It was from these demands per block that the three different distributing systems were worked out. These three systems were:

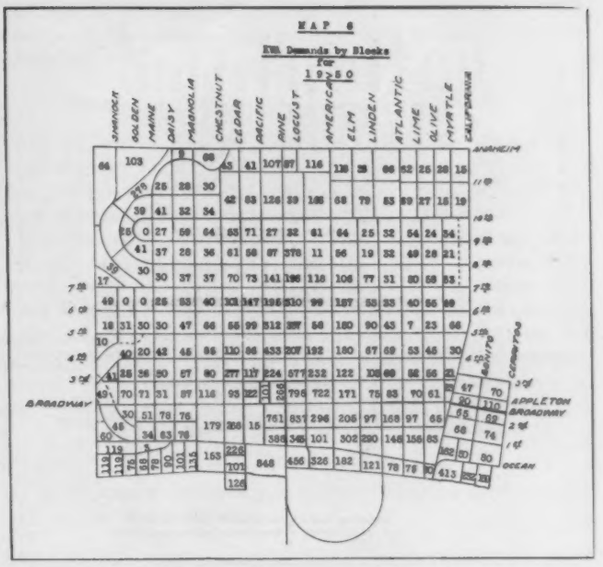



*Fig. 7. Loads in each block computed from the demand factor for each classification and the estimated percentage of each in the 235 blocks.*

4-kv. radial.
4-kv. network.
4 and 11-kv. network.

Large maps showing the existing underground system and the estimated loads for 1950 were prepared. The secondary system was planned and vaults located so as to keep the secondary drop within 3 per cent. The vaults were located along the streets where the heavier loads are expected. This also helped to simplify the primary system and keep the duct system down to a minimum. The secondary systems for both networks were the same; the radial system's secondaries were different, being six-wire instead of four and the arrangement of vaults was slightly changed. The transformer capacity to supply the load to be fed by each vault was determined.

The next step was to lay out the primary system to take care of the load at the vaults. For the two 4-kv. systems, the same 11-kv. to 4-kv. substation locations, capacities and number of 4-kv. feeders were used. There was some difference in the arrangement of the feeders, however, it being necessary with the network system to provide that adjacent vaults should not be fed from the same primary. The 4 and 11-kv. network made use of the 4-kv. feeders from Pine Avenue substation to feed as much load as possible close to the station, the balance being taken care of by 11-kv. feeders. It was necessary, also, to plan the 11-kv. lines to feed the new 11-kv. to 4-kv. substations.

The final step was to lay out the duct system and manholes to provide space for all necessary cables. Extra space was allowed for street light control primaries, telephone and telltale systems and some spare ducts in case of burn-outs or unusual load developments.

The cost to install the underground services and the salvage from the overhead system were not included in the estimate. A careful check showed that the one was approximately equal to the other, and, of course, these items would be the same for all three systems.

Both the 4-kv. radial and the 4-kv. network required two new substations in addition to three feeders from the existing Locust substation and ten from Pine Avenue substation. A total of 22 4-kv. feeders would be required to supply the underground load of 23,101 kva. anticipated for 1950.

The 4 and 11-kv. network did not require any new substations, although the full capacity of Pine Avenue sub-

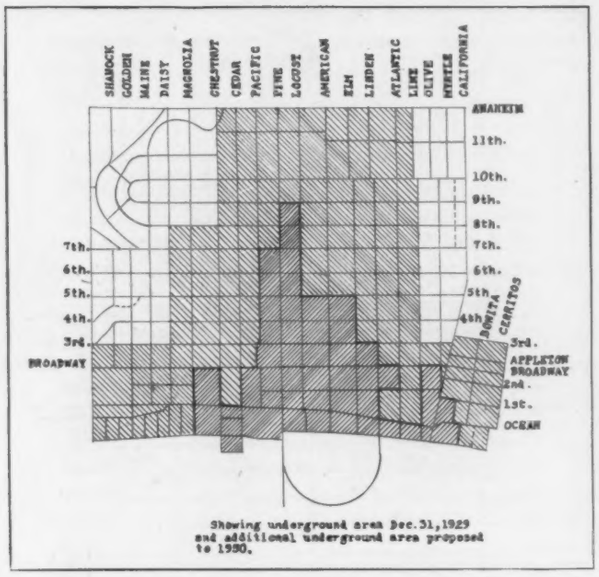



*Fig. 8. Showing underground area as existant in 1929 and as estimated for 1950, downtown area, Long Beach.*

station and all its 4-kv. feeders were to be utilized. Six 11-kv. lines were planned to take care of the load, two from each of three sources. Two of these feeders fed only underground vaults, the other four fed a few vaults and also supplied energy to Pine Avenue substation. The secondaries from both 11-kv. and 4-kv. transformers were all tied together in one network.

### Area Under Consideration

Fig. 8 shows the underground area as existant in 1929 and as estimated in 1950. The shaded central portion of this map indicates the underground area as of December 31, 1929. The surrounding shaded portion is included in the proposed 1950 underground system. The entire area shown on this map was studied. It consists of 235 city blocks covering an area of 1.6 sq. mi. The present underground system covers .28 sq. mi. and the 1950 system 1.15 sq. mi.

In determining the boundaries of the 1950 underground area a great many blocks were included which of themselves would not have sufficient load to justify underground construction, but because of the importance of certain major boulevards and business streets, these sections were included.

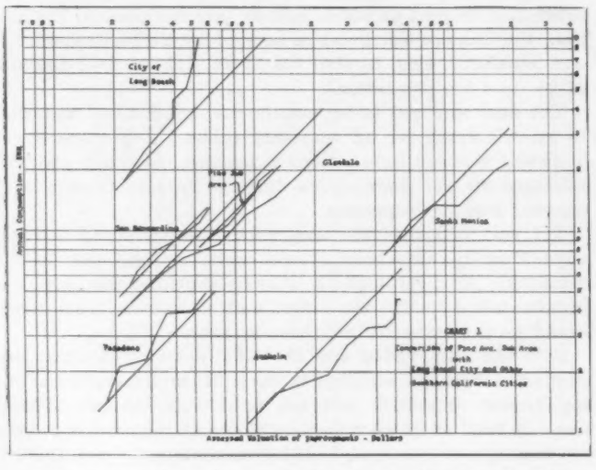



*Fig. 9. Annual kw.-hr. consumption and assessed valuation, Long Beach.*

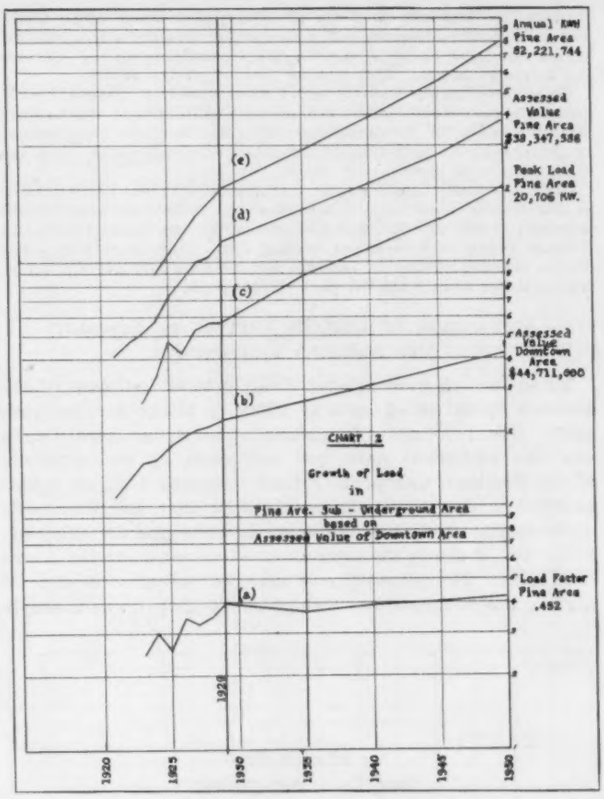



*Fig. 10. Growth of load in Pine Avenue substation area based on assessed valuation of downtown area.*

### Assessed Valuation as an Index to Annual Kw.-hr. Consumption

Fig. 9 represents annual kw.-hr. consumption and assessed valuation.

These curves give a comparison of the Pine Avenue substation area, Long Beach City and several other southern California cities. In each case the annual kilowatt-hour

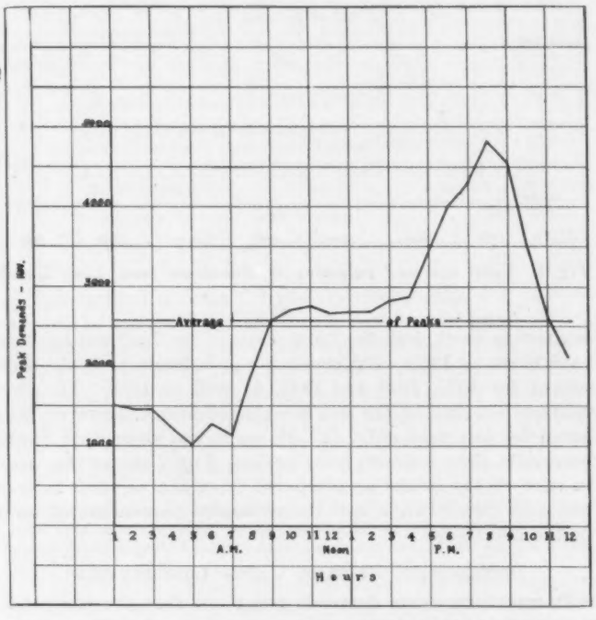



*Fig. 11. Hourly peaks for a typical day during 1929 at the Pine Avenue substation.*

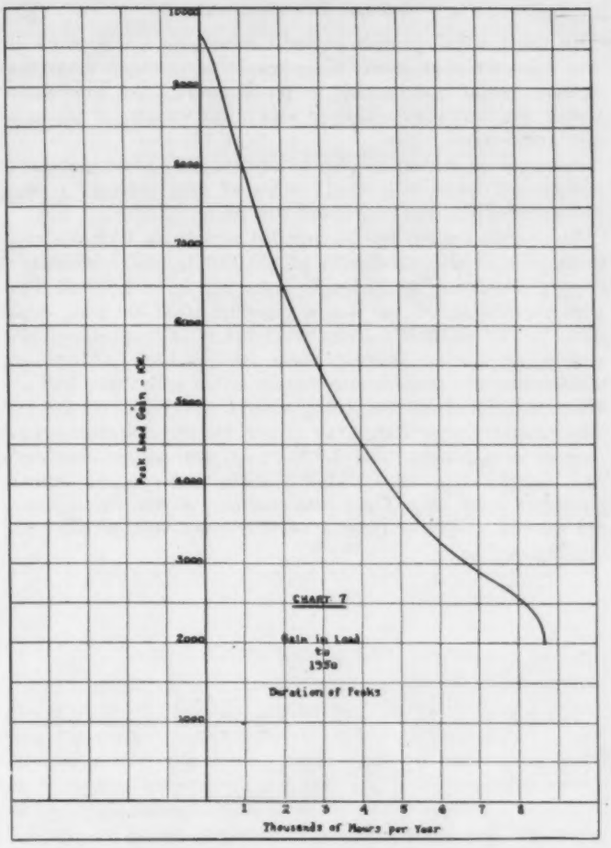



*Fig. 12. Total length of the time of duration of peak loads for the entire year.*

consumption, or output, is plotted against the assessed valuation of improvements. The straight lines at forty-five degrees indicate constant values of kilowatt-hours per dollar.

In the entire city of Long Beach the annual consumption of electric energy is increasing at a much faster rate than the assessed valuation, while in the present Pine Avenue substation area and the other cities, the increase in kilowatt-hours is about equal to or less than the increase in assessed valuation. So the consumption for the 1950 underground area will show considerable gain because it will include some of the area where the rate of increase is very rapid.

### Check of Foregoing Estimates

Fig. 10 shows growth of load in Pine Avenue substation area based on assessed valuation of downtown area.

The results for 1950, as shown on this figure, were not used in laying out the distributing systems but merely as a means of checking the totals of other detailed estimates. It would have been impossible to have extended any of the curves from 1929 to 1950 from the figures available prior to 1929 with any degree of accuracy.

The figures for assessed valuation of the downtown area were estimated for us by the statistical engineering firm. (This curve is the second from the bottom.) All the other curves have rates of increase based on increases in assessed value.

### Forecast of Demand in Kva.

The hourly peaks for each day during the year 1929 were studied and charts were made for one typical day during each of the four seasons of the year (Fig. 11). The hourly readings on these four charts were averaged, giving an hourly demand curve for a typical day for 1929. It was decided that the shape of this curve would be used in the 1929 calculations, although the values would be higher for each hour and that the peak load would be approximately 24,000 kva.

### Forecast of Kw.-hr. Consumption

Fig. 12 shows the total length of time of duration of the peaks for the entire year. The maximum peak occurs for a very short time, while the hourly peak readings never fall below a certain point at any time during the year.

The total annual kilowatt-hour loss for each of the three systems was obtained with the use of this curve in conjunction with the ones shown on the following chart. The curve was divided into short time intervals and the average demand for each of these intervals determined. Then the loss at each of these demands was found and all of them added together and multiplied by the number of hours in the interval.

### Forecast of Losses

Fig. 13 shows the core and copper losses at any load for each of the three systems:

4-kv. radial.
4-kv. network.
4 and 11-kv. network.

The 4 and 11-kv. network shows considerably less loss, both core and copper, than either of the other systems.

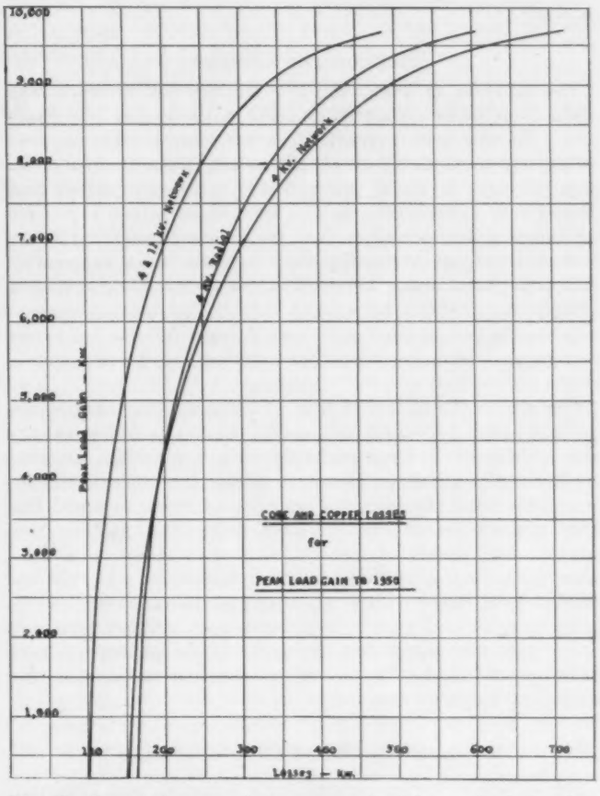



*Fig. 13. Core and copper losses at any load for each of the three systems.*

### Comparison of Systems

Table III shows the economic comparison of the three systems. Since the existing system is 4-kv. radial, it was used as the basis of comparison, or 100 per cent.

The 4-kv. network shows 14 per cent greater capital cost and the 4 and 11-kv. network 7 per cent less than the 4-kv. radial system during the next twenty years. Network pro-

TABLE III
Economic Comparison of Systems

| | 4-Kv. Radial Percent | 4-Kv. Network Percent | 4 & 11-Kv. Network Percent |
|---|---|---|---|
| Twenty-Year Costs, 1930-1950: | | | |
| Capital Investment | 100 | 114 | 93 |
| Annual Costs, 1950: | | | |
| Operating and Maintenance Expense: | | | |
| Underground System | 100 | 139 | 135 |
| Substations | 100 | 100 | 45 |
| Lost Power: | | | |
| Kw. | 100 | 118 | 80 |
| Kw.-hr. | 100 | 105 | 73 |
| Depreciation Annuity | 100 | 121 | 97 |
| Federal Tax | 100 | 114 | 93 |
| State Tax | 100 | 114 | 93 |
| Interest on Investment | 100 | 114 | 93 |
| Total Annual Charges | 100 | 114 | 88 |

tectors and other special equipment add considerable cost to any network system and no saving could be shown until the cost of the two 11-kv. to 4-kv. substations was eliminated as in the 4 and 11-kv. network.

For total annual charges for 1950, the 4-kv. network shows 14 per cent greater cost and the 4 and 11-kv. network 15 per cent less than the 4-kv. radial. The annual operating and maintenance expense was quite high for both network systems. This was due to an extra allowance being made for the services of an engineer to look after the protectors and keep a careful check on the system at all times. The largest percentage saving for any of the items occurs under substation operation. The cost for kilowatt-hour losses also showed considerable saving for the 4-kv. and 11-kv. network system.

### Decision for Adoption

The decision to adopt the low voltage a.c. network was made from these estimates together with several other factors. In the past several large consumers had required emergency methods of obtaining service from feeders other than the ones to which the load was connected. These had proved very satisfactory, but in some cases rather expensive for the very few occasions that they were necessary. These feeders acting as a standby were in some cases necessarily underloaded in order to provide for this emergency, and while of considerable advantage, still did not meet the necessary emergency in case of a transformer failure. The low voltage a.c. network seemed to fulfill all of these requirements.

The city of Long Beach was building a large auditorium and had asked for emergency service that was rather expensive to deliver. If the installation of a low voltage a.c. network was the ultimate scheme to adopt, it seemed advisable to make a start as early as possible, in order to avoid the later rearrangement and cut-over after the system had grown. The period of twenty years was taken as a date when some such a system would be demanded. All the estimates were based on the gradual growth of either of the three systems and upon the present uses of electrical service. Any additional improvements in utilization of this service would tend to lessen this period and to increase the saving as shown by this study.

### Standard Equipment to Be Installed

The standard system transformer adopted was 300-kva., 3-phase, with 1,200-amp. network protectors. The standard secondary cable to be used was 250,000 circ.mil with two sets in parallel where necessary. The voltage of the secondary network was to be 120/208-volt, 4-wire.

It was not intended, however, to replace any existing secondary of larger than 250,000 circ.mil if the current supplied, in the event of a fault, would be sufficient to burn it clear. The standard cable size on the secondary system previous to this time had been a maximum of 500,000 circ.mil.

### Initial Installation

In the gradual growth of the low voltage a.c. network it was expected that small areas would be changed from the present radial distribution to the network. As previously stated, the first one considered was in the vicinity of the new city auditorium.

In order to obtain an idea of the magnitude of the short circuit and phase-to-ground values of this system, it was set up on the calculating board for study.

The initial system will be supplied with three 4-kv. feeders, from Pine Avenue substation, of 300,000-circ.mil, 3-conductor copper cable, varying in length from 962 ft. to 2,303 ft. The Pine Avenue substation has a capacity of 12,000 kva., supplied by two parallel feeders at 11,000 volts from the steam generating plant. One of these feeders has 4,105 ft. of 350,000-circ.mil, 3-conductor copper cable and 7,320 feet of 4-0 copper overhead line, being a total distance of 11,425 ft. The second feeder has 4,148 ft. of 350,000-circ.mil, 3-conductor, copper cable and 7,770 ft. of 4-0 copper overhead line, being a total of 11,918 ft. Each feeder at the steam plant has a 400-amp., 5 per cent reactor. At the steam plant the normal supply is from a 66,000/11,000-volt, 39,000-kva. transformer bank.

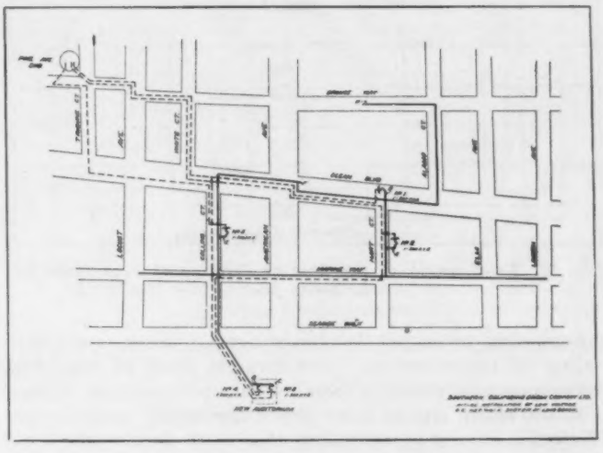


*Fig. 14. Initial installation of low-voltage a.c. network with the three 4-kv. feeders and secondaries.*

Fig. 14 shows the initial installation of this low-voltage a.c. network with the three 4-kv. feeders and secondaries. Transformer locations are shown at points Nos. 1, 2, 3, 4 and 5, all being standard 300-kva., 4,000-volt, 3-phase transformers, connected Y-Y.

### Calculation of Fault Currents on Initial Low Voltage A.C. Network

Assumed faults are shown at locations marked A, B, C, D, E, F, H and I.

The percentage reactance method was employed in calculating the fault current in the initial Long Beach network. Calculations were based on the assumption that limitation of fault currents would be due entirely to inductive reactance of the circuit and transformers, as only a direct current calculating board was available for this study.

To neglect the resistance and capacitive reactance components gives a higher value on fault currents, so to compensate for this higher value, the calculations should be reduced as much as 20 per cent. This was decided after having calculated 3-phase faults at the extreme point on the branch away from the network, including both resistance and reactance.

TABLE IV

Calculation of Fault Currents in Initial Installation of Low Voltage A. C. Network System at Long Beach,

| Location | Ground Fault | 3-Phase Fault | Current Amps. | | | | |
|---|---|---|---|---|---|---|---|
| | Total Amps. | Total Amps. | Supplied by Transformer | | | | |
| | | | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 |
| A | 26,400 | ..... | 5,200 | 18,400 | 200 | 520 | 2,080 |
| | ..... | 31,300 | 7,650 | 13,200 | 1,040 | 1,200 | 7,820 |
| B | 26,200 | ..... | 18,100 | 5,220 | 156 | Neg. | 2,230 |
| | ..... | 30,300 | 13,200 | 8,000 | 1,530 | 1,530 | 5,350 |
| C-D | 32,700 | ..... | 140 | 140 | 14,600 | 15,300 | 1,910 |
| | ..... | 34,400 | 1,950 | 1,950 | 12,850 | 12,850 | 4,170 |
| E | 24,200 | ..... | 2,080 | 1,740 | 1,040 | 1,250 | 18,200 |
| | ..... | 31,300 | 5,420 | 4,860 | 3,750 | 3,750 | 13,400 |
| F | 13,900 | ..... | 6,950 | 2,080 | 140 | 140 | 4,170 |
| | ..... | 23,600 | 8,350 | 5,430 | 1,740 | 1,740 | 6,120 |
| H | 2,780 | ..... | ..... | ..... | ..... | ..... | ..... |
| | ..... | 5,720 | ..... | ..... | ..... | ..... | ..... |
| I | 2,430 | ..... | ..... | ..... | ..... | ..... | ..... |
| | ..... | 4,860 | ..... | ..... | ..... | ..... | ..... |

### Factors Considered in Calculation

All calculations are on a 5,000-kva. base. The positive phase sequence reactance, being the reactance in a 3-phase fault, from the system to the 4-kv. bus at Pine Avenue substation, is 6.57 per cent. Three-conductor cables are used in the 4-kv. feeders, so the equivalent spacing was based on an insulation thickness of 8/64 x 8/64 in.

Negative phase sequence reactance, being the reactance due to phase-to-phase faults, was assumed to be the same as positive sequence reactance due to the absence of any amount of rotating machinery involved.

This reactance varied from 0.69 per cent on the short feeder to 1.69 per cent on the long feeder, depending also upon the location of the network transformer from the 4-kv. bus at Pine Avenue substation. The secondary cables are single conductor and it was assumed they would form an equilateral triangle when in the duct. For the 500,000-circ.mil cable the equivalent spacing is 1.4 in. and for the 250,000-circ.mil cable the equivalent spacing is 1.1 in. Positive phase sequence reactance for the 500,000-circ.mil cable is 33 per cent per 100 ft. and for the 250,000-circ.mil cable 35.3 per cent per 100 ft.

The zero phase sequence reactance, being the phase-to-ground reactance on phase-to-ground faults, from the system to the 4-kv. bus at Pine Avenue substation is 1.4 per cent.

In calculating the equivalent conductor for zero phase sequence reactance on the 4-kv. cables, the distance between conductors was taken as 0.88 in. (300,000-circ.mil cable) and due to the fact that the neutral is carried in the same duct and bonded to the cable sheath, the ground return plane was assumed to be 4.5 in.

The reactance of the 4-kv. cables varied from 3.8 per cent to 9.5 per cent, depending upon the location of the network transformers from the 4-kv. bus at Pine Avenue substation.

Zero phase recactance for the secondary, 250,000-circ.mil cable was calculated on the basis of 1.1 in. between conductors and a ground plane of 8 in. This ground plane of 8 in. was assumed, due to the fact that in some cases the neutral is in a duct separate from the cables. A distance of 1.4 in. was taken between conductors of the 500,000-circ.mil cable, using the same ground plane as the 250,000-circ.mil cable. The reactance of the secondary, 250,000-circ.mil cable is 100 per cent per 100 ft., two 250,000-circ.mil cables in parallel show 158 per cent, and the 500,000-circ.mil cable is 149 per cent per 100 ft.

### Results of Calculation

Faults were assumed at locations indicated by letters A, B, C, D, E, F, H and I, (Fig. 17) and under each fault condition total currents were calculated and also the amount of current supplied to the fault from each transformer in the network. These currents are shown in Fig. 18, and are the currents before deducting 20 per cent for the resistance and capacitive components.

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# *Movement of Lead Covered Cables Due to Load Heating**

*A series of laboratory and field tests on various arrangements designed to correct sheath wear have indicated that much can be done to improve the situation. The following conclusions are drawn from the data presented:*

1. *The best results are obtained from a long manhole with a wide offset and poorest results from a long manhole and a small offset.*
2. *The best shape for the cable in the manhole is found when it takes a curvature somewhat on the order of the loop typically used in steam pipe expansion bends.*
3. *Definite relief can be provided to the lead sheath of the cable under the unfavorable conditions found in the Oakland situation, by insertion of four sylphon bellows expansion joints in the sheath at the bends just inside the manhole and adjacent to the splice.*
4. *Expansion joints placed in the lead sheath alone do not relieve the strain from the cable insulation, nor prevent its movement within the sheath. To provide for this latter feature, an expansion joint in the copper conductor must be used.*

WHEN cables are loaded, the heat generated causes expansion of the copper conductor. In the case of lead covered cables this heating likewise causes expansion of the lead sheath. These facts have been generally recognized for a number of years. An allowance has usually been made in the design and installation of cables in subway systems in order to avoid damaging. Reports on the expansion of cables were published in the N.E.L.A. bulletin and in other publications as early as 1920, but all of these earlier papers dealt with wearing of the sheath at the duct ends, while most of the trouble in the past has been confined to large single-conductor cables of 1,000,000 circ.mil and larger and has usually occurred on low voltage d.c. systems.

### General and Historical

The N.E.L.A. underground committee's reports for 1923 and 1924 indicate the seriousness of this condition. These reports cover cables of 6 kv. and over, however, and do not include the larger conductor cables, which predominate in the systems of lower voltage and where greater movement and greater likelihood of damage are to be expected. In the 1923 report 36 failures, out of a total of 484, were due to wear on the edge of the duct at the duct ends, while in 1924 there occurred 70 out of a total of 716. The report of this same committee for the year 1928 shows 98 such failures out of a total of 850.

Various schemes have been suggested and applied for the correction of sheath wear, such as installation of rollers at the duct ends, or the insertion of a softer material between the duct and the cable. An interesting article by F. L.

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* Report presented by R. R. Cowles, chairman of subcommittee on movement of lead covered cables, underground systems committee, Engineering Section.

Rohrback, of the Washington Water Power Company, Spokane, was published in the Journal of Electricity, March 15, 1926. This article describes in some detail the type of roller adopted by that company and also tests which were made on various kinds of duct and protection before the adoption of rollers. He reports that cushions of wood, copper, lead or zinc, placed under the cables at the duct ends, are of great help, but that in many cases they fail of their purpose, and are objectionable for several reasons. In all cases they decrease the ventilation space, and unless fastened rigidly to the cable, they can, and frequently do, work out, leaving the sheath to take the wear. They are useless when the cable creeps, a condition which can occur even on very slight grades.

More recently attention has been turned to shaping the manholes so that the cables can be trained into advantageous positions, thus permitting them to assume their natural shapes and at the same time endeavoring to reduce the lateral movement to a minimum value. This method of correction recognizes the fact that considerable damage to the sheath has in recent years been found to occur in crystallization rather than wear at the mouth of the duct.

Creeping of cable, when installed on a slope, has been anticipated for a number of years and provision made to meet it. It is more serious in the case of risers to the overhead system and it has been the practice of the Pacific Gas and Electric Company to anchor the lead sheath in the manhole at the lower end.

Various types of anchorages have been used, but the one which has been in use more recently consists of a flexible copper cable wiped directly to the sheath and anchored to an eye bolt in the wall of the manhole. This method has been found effective in preventing cumulative movement, but it has introduced other complications which will be mentioned later.

### The Oakland Situation

In 1922 this company commenced the installation of about 32 mi. of 500,000 circ.mil three-conductor 11-kv. cable as substation feeders in Oakland and in San Francisco. This was sector conductor, insulated with 6/32 x 4/32-in. paper with 9/64-in. pure lead, and was for the most part installed in 4-in. fiber conduit. Preliminary calculations indicated that the expansion and contraction between no load and full load would be of appreciable importance and the manholes were designed so as to provide a gradual and easy sweep to the cables in their course around the walls. No unusual precautions were taken for the protection of the sheath at the duct ends, since we had no particular trouble at this point and our simple practice of inserting a lead collar between the cable and the duct has proven effective.

In September 1925, about three years after the first installation in Oakland, an inspection between Stations "D" and "K," disclosed breaks in the lead sheath in one of the manholes. In 1926 two more breaks were discovered in the same line, in 1927 three, in 1928 eleven, in 1929, five, and in 1930, 10, making a total of 33. Fortunately, these breaks were discovered before moisture had an opportunity to penetrate the insulation; hence no electrical failures have resulted on any of these cables.

There are four cables between Station "D" and "K" installed in a six-way duct line of 4-in. fiber conduit; the length of each cable being 12,000 ft. There are 38 manholes in this run, and the length of each cable section varies from 163 ft. to 420 ft. Half of this distance is on a slope of less than 2 per cent and no breakages have so far been found in this section. For the remainder of the distance, the duct line has a slope varying from 3 to 30 per cent and follows a winding narrow road where it has been found necessary to reduce the length of cable sections, averaging less than 300 ft., and running as low as 163 ft. It is in this steeper section, having the shorter lengths of cable, that most of the breaks have occurred. Fig. 1 shows the location of the manholes involved in this section, the distance between them, and the elevations. Sixteen of the 33 breaks have occurred in the short section between manholes 1031 and 1034, a total distance of 682 ft., with an average grade of 11 per cent. Seven have occurred in the section having a 7½ per cent grade and the remainder are distributed.

The loads carried by these cables are not excessive, although there is considerable variation between maximum and minimum loads. The four cables usually operate in parallel and carry about 415 amp. each over the peak, reach-

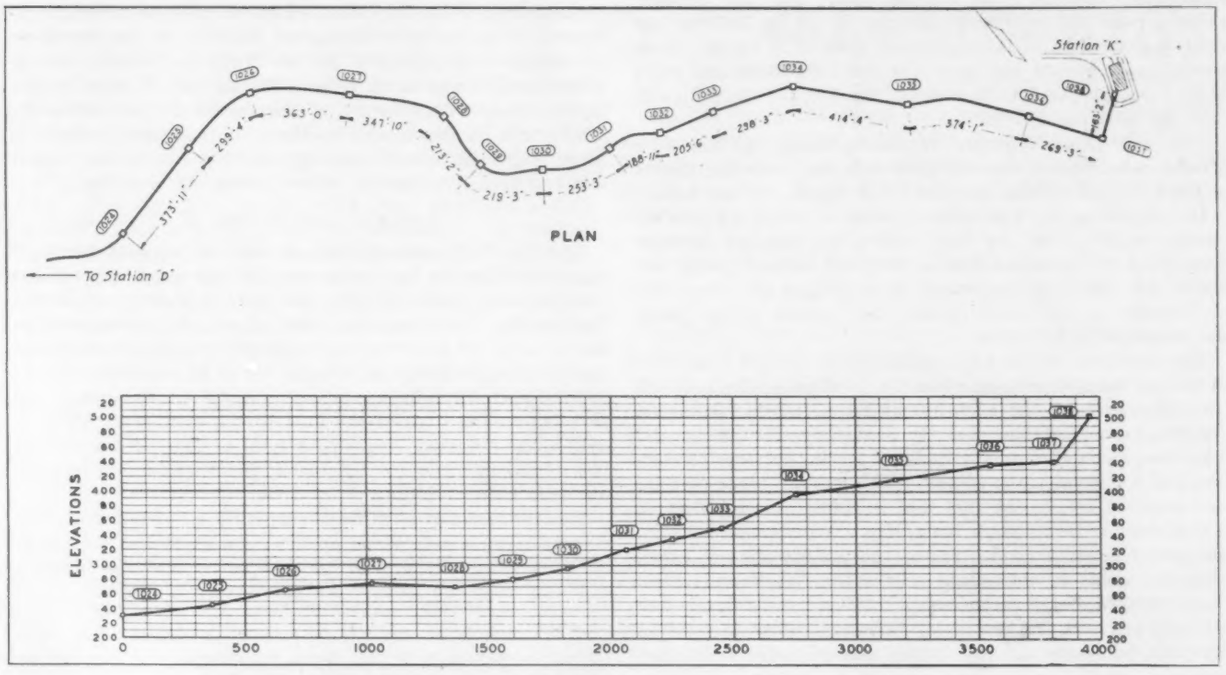



*Fig. 1. Location and elevations of portion of D-K conduit line.*

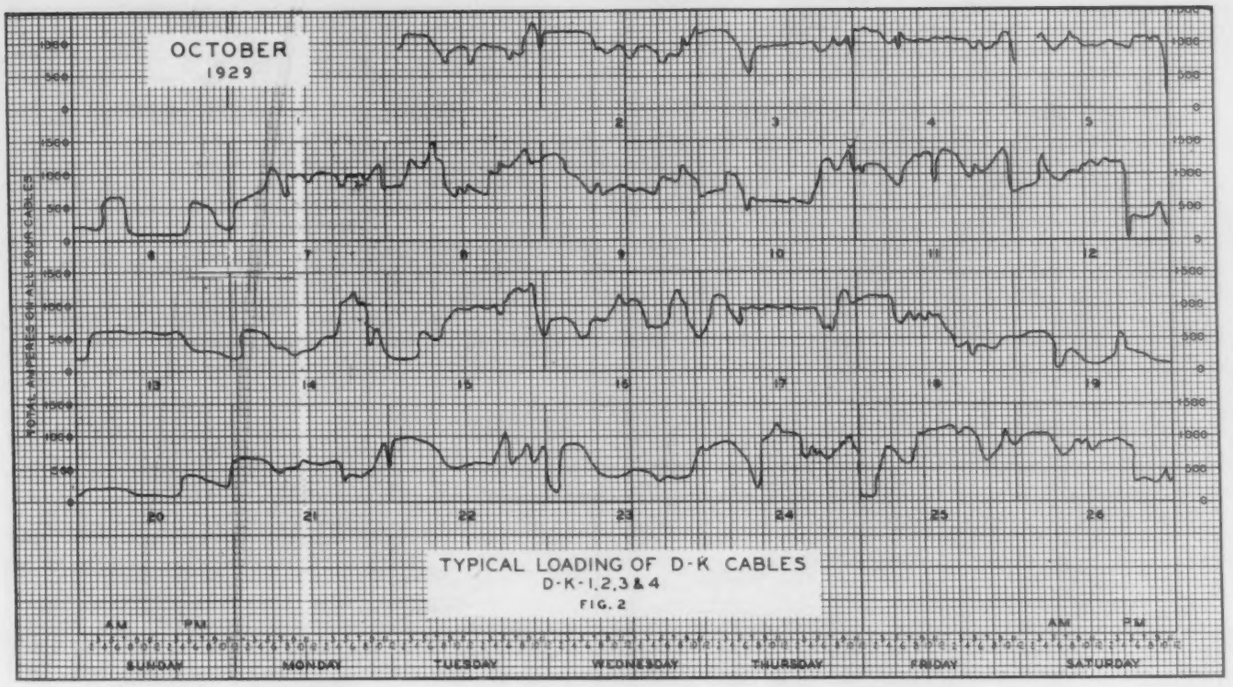



*Fig. 2. Typical loading of D-K cables.*

ing a minimum as low as 10 amp. within the same 24-hr. period.

As shown in the curves in Fig. 3, the observed temperature variations are not excessive, a maximum of 40 deg. C. and a minimum of 17 deg. C. being the widest variation observed in any one 24-hr. period.

### Field and Laboratory Tests

In the latter part of 1929 some preliminary tests and investigations were started in the manholes in which the breakage was occurring most frequently. It was obvious that the increased age of these cables was having some effect. A check showed that the DK-1 cable had the greatest number of breaks, although no condition had been found in the field which would account for this. The first test consisted in recording the movements, both lateral and longitudinal, using a stiff white paper attached rigidly to the center of the splice, and an ordinary lead pencil in contact with the paper and attached to a spring fastened to the wall of the manhole just above the paper. This method was crude but it gave us some interesting information which later proved to be of value.

Some time later tests were made with a more elaborate device, using two Bristol curved drawing voltmeters with 24-hr. circular charts. The instruments were installed flat in the manhole and in close proximity to the splice. A stout non-stretchable string was attached to the splice and run to the pen on the chart and a rubber band was connected to the string to hold it taut. The readings from these charts have been transcribed to other sheets to which have been added load curves and temperature readings. See Fig. 3. The temperature was recorded by means of a 7-day curve-

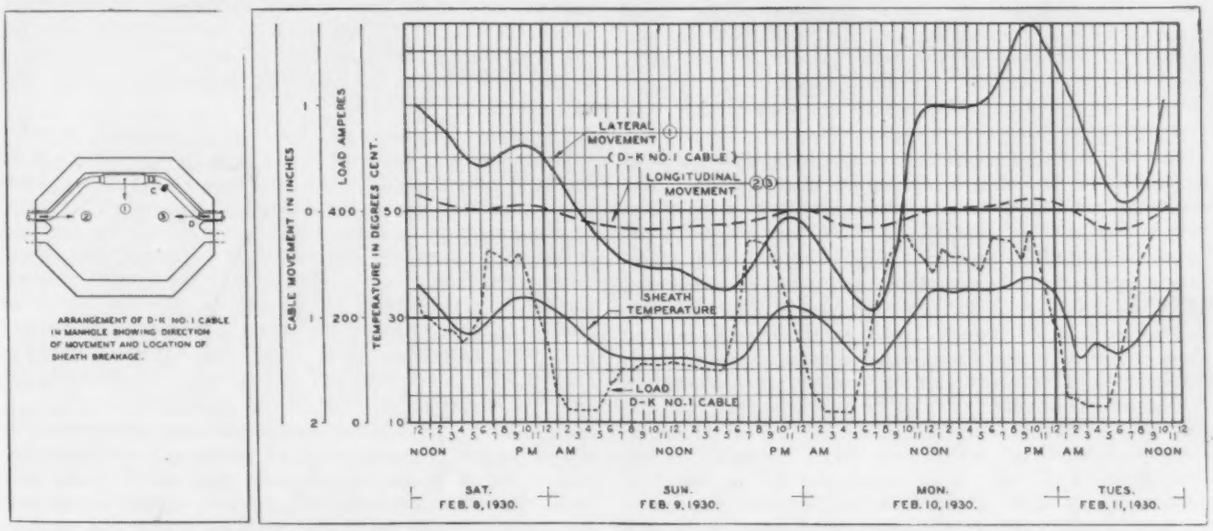



*Fig. 3. Relation between load, sheath temperature and cable movement in manhole No. 1034.*

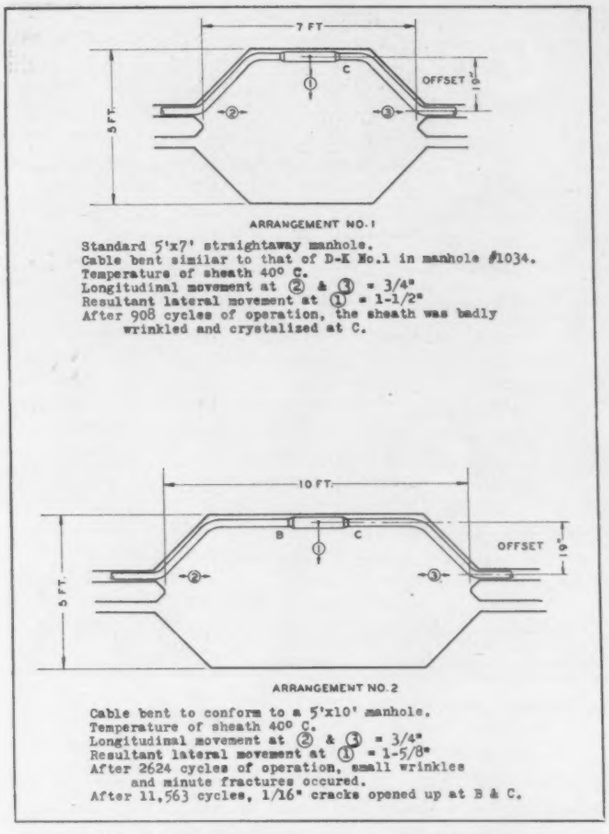

7 FT.
C
OFFSET
5 FT.
ARRANGEMENT NO. 1
Standard 5'x7' straightaway manhole.
Cable bent similar to that of D-K No.1 in manhole #1034.
Temperature of sheath 40° C.
Longitudinal movement at ② & ③ = 3/4"
Resultant lateral movement at ① = 1-1/2"
After 908 cycles of operation, the sheath was badly wrinkled and crystalized at C.
10 FT.
B
C
OFFSET
5 FT.
ARRANGEMENT NO. 2
Cable bent to conform to a 5'x10' manhole.
Temperature of sheath 40° C.
Longitudinal movement at ② & ③ = 3/4"
Resultant lateral movement at ① = 1-5/8"
After 2624 cycles of operation, small wrinkles and minute fractures occured.
After 11,563 cycles, 1/16" cracks opened up at B & C.

*Fig. 4. Laboratory tests, arrangements 1 and 2.*

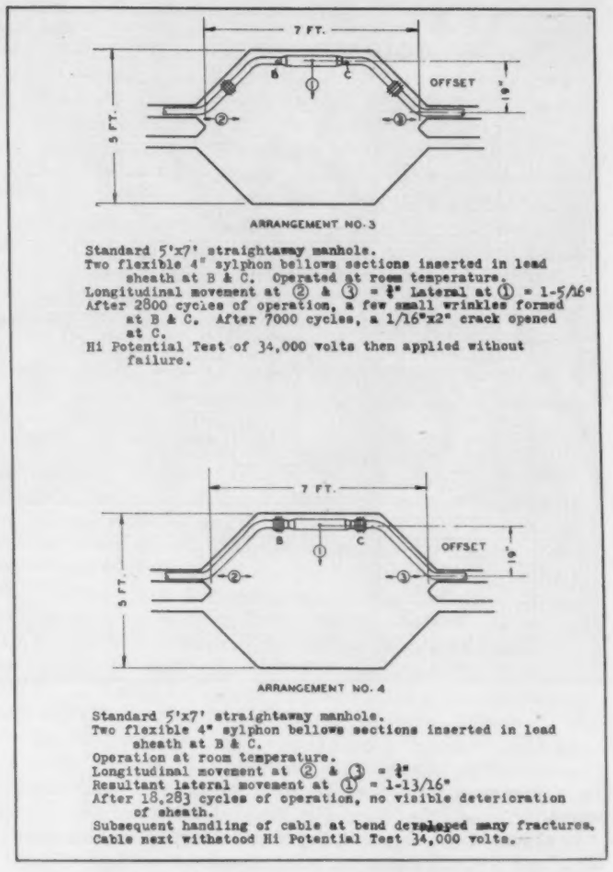

7 FT.
B
C
OFFSET
5 FT.
ARRANGEMENT NO. 3
Standard 5'x7' straightaway manhole.
Two flexible 4" sylphon bellows sections inserted in lead sheath at B & C. Operated at room temperature.
Longitudinal movement at ② & ③ = 1/2" Lateral at ① = 1-5/16"
After 2800 cycles of operation, a few small wrinkles formed at B & C. After 7000 cycles, a 1/16"x2" crack opened at C.
Hi Potential Test of 34,000 volts then applied without failure.
7 FT.
B
C
OFFSET
5 FT.
ARRANGEMENT NO. 4
Standard 5'x7' straightaway manhole.
Two flexible 4" sylphon bellows sections inserted in lead sheath at B & C.
Operation at room temperature.
Longitudinal movement at ② & ③ = 1/2"
Resultant lateral movement at ① = 1-13/16"
After 18,283 cycles of operation, no visible deterioration of sheath.
Subsequent handling of cable at bend developed many fractures.
Cable next withstood Hi Potential Test 34,000 volts.

*Fig. 5. Laboratory tests, arrangements 3 and 4.*

drawing thermometer, whose bulb was soldered to the sheath of the DK-1 cable in manhole 1038, just west of Station "K." While this temperature does not necessarily give the maximum possible temperature of the sheath at the hottest spot of the hottest cable, it nevertheless is an indication of the variation of temperature, and the information obtained from these tests proved to be of considerable value in the studies which followed. The maximum movements as recorded by these tests indicated a longitudinal movement of the cables at the edge of the duct of 0.72 in. and a resultant lateral movement of the splice back and forth from the wall of 2⅝ in. The relationship between the longitudinal movement of the cable and the lateral movement of the splice will vary with different types and shapes of manholes and different arrangements of the cables within the manholes. Calculations of expansion were made, based on the temperatures observed and estimated, and these values checked very closely with the values found in the field.

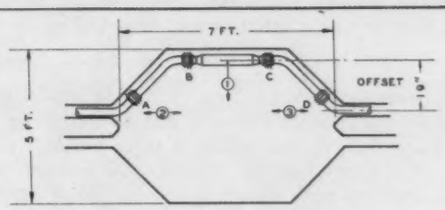
With the above information, available tests were begun in the laboratory in order to determine what methods could best be applied to remedy the situation existing on the cables between Stations "D" and "K," and to make provision for the installation of future cables of this size and even larger.

By using motor driven devices, reciprocating motion was applied to cables set up in various shapes, causing the cable to compress from its two ends, resulting in the splice moving laterally just as it was found to have done in the manhole. The interval of application of this motion was adjusted so as to given one complete cycle every twenty seconds, and the splices were made up exactly as in the field. Various shapes and arrangements of cables were tried; representing different length and width of manholes, and the movement of cables was carried on in each case until cracks appeared in the lead sheath. Careful examination of the sheath was made from time to time and record kept of the first evidence of crystallization of the lead. Arrangements of cables and results obtained are shown in Figs. 4, 5 and 6.

These tests produced some very valuable information. It was found that the shape, and particularly the length of the manhole, had a material bearing on the life of the cable. Longer manholes and easier sweeps naturally gave better results, but it became apparent that some means must be taken to relieve the lead sheath from the strain to which it was being constantly subjected. This relief is imperative in the case of cables already installed, and due to the fact that we were at the time about to commence the installation of several miles of 750,000 circ.mil three-conductor cable for the same voltage and same type of service, it was necessary to find something in the nature of permanent relief for the new as well as old work.

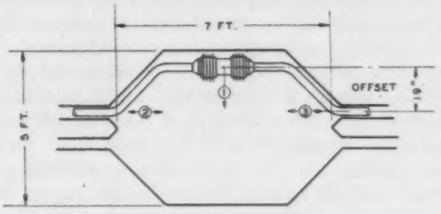
The points of maximum strain where breakage occurred were immediately adjacent to the wipe of the splice and at the bend near the duct end. Breakage at the former location is doubtless due to the rigidity of the lead at the point of attachment to the splice, while breakage near the duct end is due to the fact that the maximum bending of the sheath takes place at that point. Reduction in the amount of bending can be accomplished by keeping the cables as nearly as possible in line with the duct run. This means longer and narrower manholes. This condition, however, produces greater lateral movement of the splice and necessarily results in increased breakage at the other point.

In order to check the amount of pressure represented by the expansion or compression of cable as it occurs in the field, a 425-ft. length of this cable was pulled in the duct line between two manholes and pressure applied at one end. See Fig. 7. It was found that 1,540 lb. of pressure could be applied before any movement occurred in the cable in the




ARRANGEMENT NO. 5

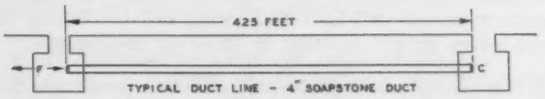
Standard 5'x7' straightaway manhole. Typical joint.
Four flexible 4" sylphon bellows at A - B - C - D.
Cable heated by applying 400 Amps. to conductors while potential of 11,000 volts was continuously applied between conductors.
Longitudinal movement at ② & ③ = $\frac{1}{2}$"
Resultant lateral movement of joint ① = 1-15/16"
After 18,456 cycles of operation, no apparent deterioration of lead sheath. After handling and bending however, many small fractures appeared.




ARRANGEMENT NO. 6

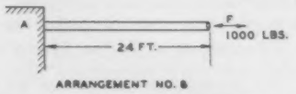
Standard 5'x7' straightaway manhole.
Special flexible cable joint with two 8" sylphon bellows in lead sleeve and flexible copper braiding in conductor splice. Heat applied externally to keep cable compound soft.
Longitudinal movement at ② & ③ = $\frac{1}{2}$"
No resultant lateral movement of splice ①.
Tested to 24,697 cycles without apparent damage to either conductors, insulators, or sheath.

*Fig. 6. Laboratory tests, arrangements 5 and 6.*



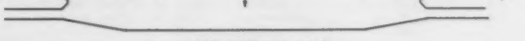

ARRANGEMENT NO. 7

Field test to determine extent to which cable will adjust itself within the duct, to compression and tension.
Cable length 425'
Compressive force of 1540 lbs. applied at F, caused movement of $\frac{1}{2}$", at that point before C moved.
Tension of 1600 lbs. at F moved 1$\frac{1}{2}$", before end C moved.




ARRANGEMENT NO. 8

Laboratory test to determine effect of compression and tension alternately applied to a straight length of cable.
Conductors and sheath wiped together at each end.
Force applied 1000 lbs. Very slight "snaking" effect observed when cable was under compression.
No apparent sheath damage after 10,169 cycles of operation.
Subsequent bending and handling developed many fractures.




ARRANGEMENT NO. 9

Bending test in laboratory on 12' length of cable with 5" of offset and no joint, to determine effect in a long narrow manhole.
Longitudinal movement at ② & ③ = 3/4"
Resultant lateral movement at ① = 4-3/4"
Current of 500 amps. applied giving 40° sheath temperature.
After 10,950 cycles of operation there was considerable wrinkling of sheath.
After 3471 cycles, wrinkles had increased to $\frac{1}{4}$" in height and one crack had opened.

*Fig. 7. Field and laboratory tests, arrangements 7-9.*

manhole 425 ft. away. This and similar tests gave us indications of the amount of pressure which it would be necessary to apply to the cable in the laboratory in order to simulate conditions occurring in the manholes.

It seemed apparent that some flexible material placed in the lead sheath at the points of breakage would relieve the strain and prevent damage. Sylphon expansion joints were, therefore, placed in the test cables at the points indicated, and various arrangements and locations of these expansion joints were tried—some in the splice, some on either side of the splice. See Figs. 5 and 6. Various methods of anchoring were tried and the tests were continued during the summer and the latter part of the year 1930.

The introduction of the sylphon expansion joint in the lead sheath materially prolongs its life. If we consider one cycle of compression and expansion of the cable as representing the equivalent of a 24-hr. period of heating and cooling, we arrive at an interval of time which we have expressed in cycles, 365 of these cycles being equivalent to one year. The analysis as well as the figures included in this report, show very clearly the results obtained by the simple introduction of these expansion devices. As far as the lead sheath was concerned, we felt that this type of device would effectively solve the immediate problem.

We are not certain, however, as to the effect on the conductors and more particularly on the paper insulation. In some of the tests, holes were cut in the lead sheath at the splice and in the cable, in order to determine what was happening to the conductors and insulation during the movement.

Believing that we had solved the problem of lead sheath breakage, it remained only to design a satisfactory expansion joint for the copper conductors which could be built into the splice at a reasonable price. Considerable study was given this feature and other tests were made before the joint shown in Fig. 6 was designed. This splice, combining the features of expansion in the conductors and in the lead sheaths, has been put through very severe tests and some of these splices are now being installed in Oakland in the manholes where the greatest number of breakages have occurred. We believe that, with this device, we will be able to operate these cables without difficulty to the end of their useful life. It must not be forgotten, however, that the cables between Stations "D" and "K" in the section where the troubles have occurred have been subjected to a great deal of stress and that the lead is fatigued. We may be able to prevent further breakage there by installing additional sylphon expansion joints in lead sheath only. One expansion joint in the copper conductors for each manhole will probably be sufficient, since these joints are capable of taking up the maximum amount of expansion that is likely to occur in any of the lengths installed or to be installed.

From an analysis of the test results, it is seen that all the remedial measures attempted were effective to some extent. The different methods are tabulated, in the order of their relative merits, in the following manner:

*The Arrangement No. 6, Fig. 6, flexible joint*—Eliminates all bending, transverse motion and mechanical strain of the cable.

*Arrangement No. 5, Fig. 6, four flexible bellows sections in sheath*—Relieves the sheath bending very effectively, but does not relieve the cable of transverse motion.

*Arrangement No. 4, Fig. 5, two flexible bellows sections in sheath, adjacent to the cable joint*—This is quite effective in relieving the sheath, though not as efficient as No. 5.

*Arrangement No. 3, Fig. 5, two flexible bellows sections in sheath, midway between cable joint and duct opening*—This aids in relieving the sheath, but not as effective as No. 4.

*Arrangement No. 2, Fig. 4, bend enlarged to fit a 5 x 10-ft. manhole*—This method aids in relieving the cable, though not as effectively as No. 3.

## Conclusions

It is premature to conclude that our problem has been permanently and definitely solved. It is safe to say that the

measures tried and which gave the best results under test will materially lengthen the life of the cable. Considerable investigation will still have to be made and the test of time given before we will feel that we have the final answer.

A few general conclusions seem to be in order at this time.

1. The best results can be obtained from a long manhole with a wide offset and poorest results from a long manhole and a small offset.

2. The best shape for the cable in the manhole is found when it takes a curvature somewhat on the order of the loop typically used in steam pipe expansion bends.

3. Definite relief can be provided to the lead sheath of the cable under the unfavorable conditions found in the Oakland situation, by insertion of four sylphon bellows expansion joints in the sheath at the bends just inside the manhole and adjacent to the splice.

4. Expansion joints placed in the lead sheath alone do not relieve the strain from the cable insulation, nor prevent its movement within the sheath. To provide for this latter feature, an expansion joint in the copper conductor must be used.

TABLE I.—Record of Sheath Breaks on 11-kv. Cables between Stations "D" and "K", Oakland, Calif. From September, 1925, to January, 1931.

| Date | Cable | Manhole | Remarks |
|---|---|---|---|
| 9-19-25 | DK-1 | No record | East of College Avenue. |
| 11-18-25 | DK-1 | No record | East of College Avenue. |
| 3-30-26 | DK-4 | No record | East of College Avenue. |
| 9- 2-26 | DK-1 | No record | East of College Avenue. |
| 9-29-27 | DK-1 | No record | East of College Avenue. |
| 12-19-27 | DK-3 | No record | East of College Avenue. |
| 12-23-27 | DK-3 | 1033 | Slope. |
| 7-24-28 | DK-3 | 1026 | Slope. |
| 7-24-28 | DK-1 | 1031 | Slope. |
| 12-11-28 | DK-3 | 1034 | Slope. |
| 12-11-28 | DK-2 | 1034 | Slope. |
| 12-11-28 | DK-1 | 1034 | Slope. |
| 12-11-28 | DK-2 | 1033 | Slope. |
| 12-11-28 | DK-4 | 1033 | Slope. |
| 12-11-28 | DK-2 | 1032 | Slope. |
| 12-11-28 | DK-3 | 1031 | Slope. |
| 12-11-28 | DK-1 | 1030 | Slope. |
| 12-24-28 | DK-2 | 1033 | Replaced section 1033 to 1034. |
| 10-16-29 | DK-3 | 1033 | Slope. |
| 10-16-29 | DK-2 | 1032 | Slope. |
| 10-16-29 | DK-2 | 1034 | Slope. |
| 10-16-29 | DK-1 | 1026 | Slope. |
| 10-16-29 | DK-1 | 1032 | Slope. |
| 1-24-30 | DK-1 | 1030 | Slope. |
| 1-24-30 | DK-1 | 1034 | Slope. |
| 1-24-30 | DK-3 | 1019 | Slope. |
| 5-15-30 | DK-3 | 1013 | Level. |
| 5-15-30 | DK-1 | 1030 | Slope. |
| 5-15-30 | DK-4 | 1033 | Slope. |
| 5-17-30 | DK-3 | 1013 | Level. |
| 6- 4-30 | DK-3 | 1026 | Slope. |
| 6-24-30 | DK-1 | 1037 | Slope. |
| 12-23-30 | DK-3 | 1017 | Level. |

TOTAL—33 Breaks.

Breaks by Manholes

| Manholes | No. of Breaks |
|---|---|
| 1013 | 2 |
| 1017 | 1 |
| 1019 | 1 |
| 1026 | 3 |
| 1030 | 3 |
| 1031 | 2 |
| 1032 | 3 |
| 1033 | 6 |
| 1034 | 5 |
| 1037 | 1 |
| Unknown | 6 |
| Total | 33 |

Breaks by Circuits

| Circuit | No. of Breaks |
|---|---|
| DK-1 | 13 |
| DK-2 | 6 |
| DK-3 | 11 |
| DK-4 | 3 |
| Total | 33 |

# *Leaded vs. Non-Leaded Cables—Suitability and Justification of the Two Forms**

*The study of the use of leaded and non-leaded cables is a much broader subject than it seems at first thought, and since the use of non-leaded cable is still in the experimental stage, conclusions drawn can only be indefinite.*

* Report of subcommittee on leaded vs. non-leaded cable, underground systems committee, Engineering Section. J. C. McClung, chairman, K. B. Ayres, C. E. Biggs, J. E. Crilly, W. K. Cullen, G. L. Hill, H. C. Keesling, C. G. Mansfield, P. J. Ost, C. C. Potts, A. C. Putnam, J. P. Robinson.

*Information herein contained has been gathered from various Pacific Coast utilities and summed up in the following:*

UNTIL recently there has been very little non-leaded cable used for distribution purposes and all companies reporting are using lead covered cable in their manhole and duct systems. For street lighting circuits, lead covered cable installed in conduits with either paper, varnished cambric, or rubber insulation is required by ordinance in some cities, but more and more of the buried non-leaded cable is being used for this class of service. For submarine cable both leaded and non-leaded types are being used. Lead covered paper insulated submarine cables seemed to be preferred in recent eastern installations.

### Trial Installations

One company reports that it is now making a few trial installations of non-armored, non-leaded trenchlay cables in subdivisions along property lines, covering the cable with a redwood plank and two or three inches of concrete protection at street crossings; it is also using trenchlay cable under a long pier with no covering. This is supported by wooden cleats. Other companies report the use of trenchlay cables with satisfactory results so far. A considerable amount of non-metallic or trenchlay cable has been used for airport and street lighting circuits. One company reports a 600-volt railway feeder, 4,000 ft. long, of non-leaded, rubber insulated cable, installed in a tunnel, with splices made in niches in the wall; this has been in service over two years without showing any evidence of deterioration. The methods of installing underground systems to supply residential tracts is about the same with all companies. That is, the tract owner or property owner pays the difference between such cost and that of an overhead system. We all feel that there must be some way found to supply the increasing demand for underground systems in the residential districts at a cost nearer to the cost of overhead construction, but if the utility must keep the system in repair and give good service, it may not be economical to use buried cables which would take away the flexibility of the present system which we have seen is so necessary, due to the rapid and irregular load changes which we are called upon to provide for. There have been many small installations of non-leaded cables using varied schemes, but we find that a large part of these are suited for the particular job only.

### Replacements

From reports there has been very little leaded cable replaced by non-leaded cable. One of the recommended uses of non-leaded cable is to prevent sheath currents and electrolysis, but from the information received, no one seems to be having much trouble with either. All seem to be bonding the cable sheaths to the neutral and water pipes and installing drains to the railway system in the few cases where required. Most companies have had trouble with rubber covered services and are using lead covered cable in replacement, also for new services. One severe case of electrolysis that was reported, was due to the bare copper neutral pulled in with two lead covered cables for service; this was overcome by using three lead covered cables. Failures of rubber covered services are partly due to the former use of a lower grade of rubber than is used at present, also many of the services which have been installed for some time are overloaded, due to the increasing use of electrical appliances.

### Comparisons

We have not been able to get any definite or worthwhile comparative costs between the buried cables and cables pulled into ducts, as there has been only a small amount of the buried cables used, except for street lighting. We do know that the first costs of manhole and ducts with cables pulled

in are much more than the buried cables and it will take some time to prove the many plans and ideas that the various companies are working on and trying out in actual practice. At the present time the buried cables are installed for approximately 65 per cent of the cost of duct and manhole system. In comparing the cost of the different classes of cable, we do not find a great difference, although it is very hard to make a just comparison. Manufacturers are continually bringing out improvements with non-leaded cables and opinions vary as to the expected life of the different types.

### Conclusions

In conclusion we might state that most utility companies at present believe that when they are required to maintain the ducts and cables, also to provide for future loads, that they are justified in installing a duct and manhole system, although the initial cost is greater than the use of buried cables, but the increasing use, throughout the country, of non-leaded cable buried directly in the ground shows that the electric utilities in general are striving to bring the cost of underground construction nearer to that of overhead construction and prove the justification of non-leaded buried cables in many places. For street lighting, where the load is almost constant, the non-metallic cables buried directly in the ground seem to be preferred; also, non-leaded cable is being used satisfactorily for airport lighting and for parks, estates, etc.—in these cases the maintenance is carried by the consumer and not by the utility. It appears that a combination of the two systems could be used, making use of service boxes in place of manholes where secondaries only are to be considered, using manholes and ducts for the main primary feeders only. Due to the fact that the manufacturers are continually bringing out improvements, also different types of non-leaded cables, a just cost comparison cannot be made. Some claim that the life of the non-metallic or trenchlay cable is practically the same as that of lead covered cable. Most cases of electrolysis can be eliminated by bonding of the lead sheaths of the cable, also non-leaded cable can be used where the size of the duct or service pipe will permit, as non-leaded cable is somewhat larger than lead covered. We believe that the non-leaded cable is still in the experimental stage and its further use will be steadily increased.

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# *Pulling Stress of Cable Through Various Types of Ducts With a Study of Various Types of Ducts, Their Merit and Application**

*This report is intended to supplement a report of the same title which was presented at the Fresno meeting of the underground systems commitete in April, 1930. The 1930 report appears on page 469 of "Proceedings, Pacific Coast Electrical Association, 14th Annual Convention," also on page 469 of the May 15, 1930, issue of "Electrical West." In presenting the following data, it is the intention to cover further observations and tests which have been made since compilation of the original report. These tests and observations have been directed, as before, to the subject of pulling stress on cable, and to the physical and chemical characteristics of duct materials to determine their comparative suitability for use in underground duct construction. The tests, it will be noted, have been confined to lead covered cable of large size (500,000 circ.mil and 750,000 circ.mil) and to conduit of 4-in. internal diameter.*

THE following tests and data supplement the 1930 report of this committee on the subjects of pulling stresses on cable and of the physical and chemical characteristics of duct materials which determine their suitability for use in underground construction.

### Physical Characteristics—Laboratory Tests

A strength test was made by crushing 18-in. sections of conduit in a testing machine. The sections were placed horizontally in a sand box to a depth of half the diameter of the conduit and the pressure applied to the upper side through a flat piece of wood the length of the section. Eight pieces of each kind of conduit were tested and the average recorded. The results were as follows:

| | Crushing Strength (Lb. per Ft. Length) |
|---|---|
| Soapstone (Std.) | 608 |
| Soapstone No. 20 | 826 |
| Soapstone No. 40 | 784 |
| Soapstone No. 140 | 762 |
| Soapstone—Asbestos | 638 |
| Concrete (San Jose type) | 870 |
| Fiber | 948 |

The soapstone and the concrete collapsed completely on failure. The soapstone-asbestos, while cracking badly, had a tendency to hold together. The fiber did not display the fragile characteristics of the others. It failed in one lengthwise crack after considerable flattening.

In addition to the crushing test just described, tests were made to find the breaking strength as a beam of these same types of conduit. The tests were made on the conduit when dry and again after submersion in salt and in fresh water. For testing, the conduits were placed as a beam, between supports 30 in. apart and a force applied at the rate of 500 lb. per minute. A graphical representation of the effect of submersion in water is shown in Fig. 1.

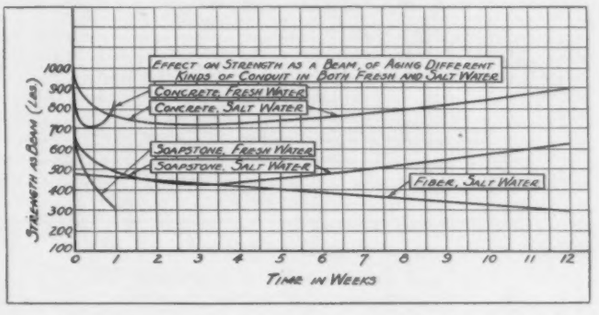


*Fig. 1. Effect on strength as a beam, of aging different kinds of conduit in both fresh and salt water.*

While for the concrete and the soapstone there was at first a decided drop in strength resulting from submersion, following that there was a gradual recovery. The fiber continued to lose strength during the length of the test. Moisture is by far the the most injurious to fiber, which after three months' submersion showed a 48 per cent loss of strength. For the soapstone at the end of three months the loss was only 10 per cent. The concrete over the same period of time showed a 7 per cent loss.

Because the fiber conduit is of a material that might be affected by heating, tests were made to find the extent in the characteristics of this material due to heating. Small pieces of fiber were heated in an oven and penetration tests

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* Report of subcommittee on conduit, underground systems committee, Engineering Section. H. C. Moyer, chairman. M. N. Clark, W. C. Curl, R. C. Harris, G. L. Hill, C. H. Jenkins, D. J. Kelly, T. T. Kennedy, G. P. Mackenzie, J. P. Robinson, Vinton Smith.

were made at various temperatures. Up to 60 degrees C. the fiber was unaffected by the heating. Above 60 degrees C. there was a slight bubbling out of the binder, but no softening of the fiber. At 80 degrees C. the binder bubbled out to a considerable extent but there was still practically no softening of the fiber.

The question immediately arose as to the extent to which a cable would stick to a duct of this kind after it had been heated sufficiently to cause an expulsion of the binder. A 30-ft. section of 4-in. fiber conduit containing a 400,000-circ.mil, 3-conductor cable was subjected to a test. An electric current was passed through the conductors to heat the cable. Each given temperature was maintained for a period of 24 hours and then allowed to cool for the same period, after which the initial starting pull necessary to break the adhesion was measured. The results were as follows:

| Temp. of Sheath (Deg. C.) | Initial Starting Pull to Break Adhesion (Lb.) | Subsequent Starting Pull (Lb.) |
|---|---|---|
| 20.0 | 213 | 213 |
| 29.0 | 600 | 350 |
| 40.0 | 1,000 | 580 |
| 54.0 | 1,050 | 300 |
| 65.3 | 1,150 | 350 |
| 100.0 | 1,600 | — |

A thermal conductivity test was made on each type of conduit material. Standard 3-ft. lengths were tested by placing heating elements inside and capping the ends. The conduit was buried in sand and the inside and the outside temperatures were measured by means of thermo-couples. See sketch in Fig. 2 for test setup. The thermal conductivity of the conduit was computed from known heat flow, temperature difference, and thickness of material. The results are plotted in Fig. 2, showing the thermal conductivity of each material, both in B.t.u. per ft. cubed per 1 degree F. per hour, and in B.t.u. per sq. ft. per 1 degree F. per hour.

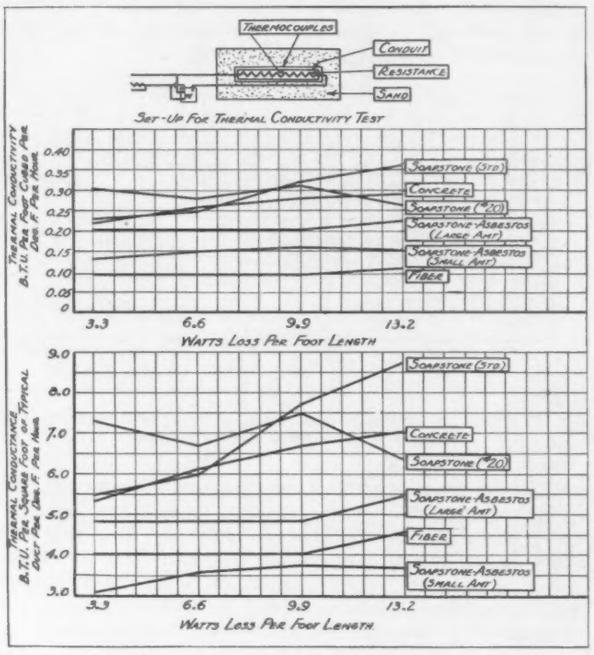


*Fig. 2. Thermal conductivity test.*

The soapstone and the concrete, having the highest rate of heat conductance, are quite evidently the best materials from the standpoint of dissipation of cable heat.

### Chemical Characteristics—Laboratory Tests

Each type of duct material was tested for its corrosive action on lead. The test was made by placing about 400 c.c of pulverized conduit material in a beaker containing water and a piece of lead. The per cent loss of weight of lead was used as an indication of the corrosive action of the materials. The contents of each beaker were held at a constant temperature of 45 degrees C. for a period of one month.

From an examination of the following tabulation of the results of the test it appears that while there is some corrosion for each material, for no one material is it to an extent that would bar its use as conduit for lead covered cable. The corrosive action of the pine sawdust, it will be noted, was small, which is quite contrary to general opinion regarding conduit with a wood content.

| | Soapstone Asbestos | Concrete (San Jose Type) | Soapsone (Std.) | Pine Sawdust |
|---|---|---|---|---|
| Original weight of lead (grams) | 30.3125 | 31.4951 | 29.3978 | 30.1805 |
| Weight after 1 week | 29.9916 | 30.9924 | 28.8247 | 30.0954 |
| Loss in weight | 0.3209 | 0.5027 | 0.5731 | 0.0821 |
| Per cent of loss | 1.06 | 1.59 | 1.95 | 0.27 |
| Weight after 1 month | 29.4518 | 30.3022 | 28.3506 | 30.0526 |
| Loss in weight | 0.8607 | 1.1929 | 1.0472 | 0.1279 |
| Per cent loss | 2.84 | 3.78 | 3.56 | 0.42 |

In another test along this same line, a 3-ft. section of 4-in. soapstone, concrete and fiber conduit were separately encased in a 1½-in. envelope of concrete with an 18-in. length of lead covered cable placed in each and filled with sea water, after which the conduit ends were sealed. The conduits were then placed on the roof of a building to remain for seven months. All were then broken open and the lead examined with a magnifying glass. On none of the samples was there any evidence of corrosion. Incidental to this test it was found that concrete will adhere to soapstone conduit as readily as it will to concrete.

A few tests were made on certain materials to apply conditions to which it was believed a specific material might be susceptible. They are outlined briefly as follows:

Samples of fiber "A," fiber "B," and fiber "C" were boiled in water for four hours. Sample "A" exuded its binder which cooled with hard rough blisters. Sample "B" split and unrolled slightly but kept its binder. Sample "C" exuded its binder but withstood the test better than the other two.

A sample of soapstone conduit was boiled in water 358 hours with no damage to it.

A sample of concrete conduit was boiled four hours. The only effect apparent was to make it slightly more rough.

A sample of soapstone conduit was soaked in crude oil for 86 days with no effect.

Samples of fiber, soapstone, and concrete were buried in graphite grease for a period of two months. There was no apparent damage to any of the materials.

### Practical Service Tests

Several practical service observations of certain materials are worthy of mentioning here.

A section of concrete duct containing a 250,000-circ.mil, 4,500-volt, 3-conductor lead covered cable which had been in service in moist ground for seven years was broken out for examination. It was found to be in good condition with no evidence of corrosionn.

A section of soapstone duct containing a 250,000-circ.mil, 4,500-volt, 3-conductor lead covered cable which had been in service 16 months in a very wet tide land was broken out for examination. Conduit and cable were found in good condition with no evidence of corrosion. A piece of soapstone duct which had been buried without concrete or other protection in very wet tide land for 22 months was uncovered and found to be in perfect condition.

### Pulling Stress

One set of tests was made to determine the comparative frictional resistance of duct material to cable pulling. A 500,000-circ.mil, 11,000-volt, 3-conductor cable was used in the test. A small amount of graphite grease was used on each section of cable. Four duct materials used for the test were: concrete (San Jose type), fiber, concrete and sawdust, and soapstone (standard). Fig. 3 shows graphically the results of the test.

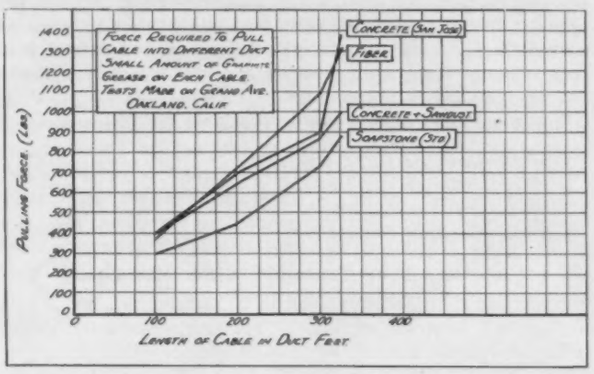
Force Required To Pull Cable into Different Duct
Small Amount of Graphite Grease on Each Cable
Tests Made on Grand Ave.
Oakland, Calif.
Concrete (San Jose)
Fiber
Concrete + Sawdust
Soapstone (Std)
Pulling Force (Lbs)
Length of Cable in Duct Feet

*Fig. 3. Force required to pull cable into different ducts.*

This test shows that the concrete and the fiber offer the highest resistance to cable pulling, and that the concrete and sawdust and soapstone offer the lowest of all. It appears from this test that soapstone is the best duct material from the standpoint of low frictional resistance in cable pulling.

Another set of tests was made to determine the value of lubricants in reducing cable pulling stress. In this test 750,000-circ.mil, 11,000-volt, 3-conductor cable weighing 16 lb. per ft. was used. All ducts were fiber, which, as shown in Fig. 3 is one of the materials which offers high frictional resistance. The cables were pulled, using: no lubricants, graphite grease, and another compound. (See Figs. 4 and 5.)

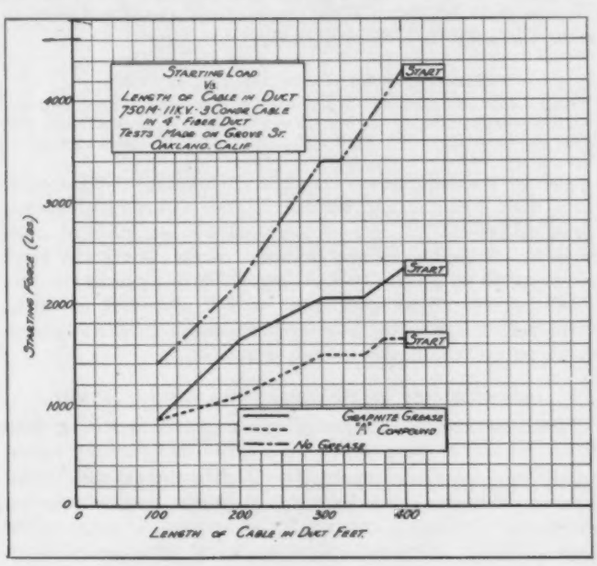


*Fig. 4. Starting load vs. length of cable in fiber duct, using different types of grease.*

While the difference in the value of the two lubricants was slight, it is evident that the use of some grease was of great value in fiber duct. The results of similar tests (Fig. 6) made at a later date in which standard soapstone, one of the materials offering low frictional resistance in the tests shown in Fig. 3, was used, are gratifying. Here the

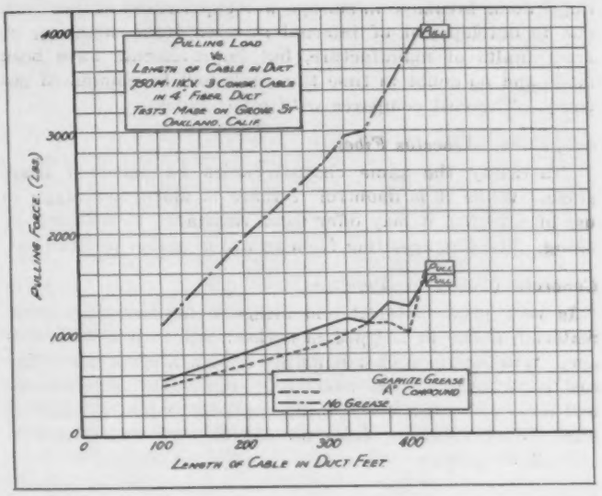


*Fig. 5. Test to determine value of lubricants in reducing cable pulling stress.*

difference between the greased and ungreased cable was of so slight a practical difference as to be almost negligible. From this it would appear that the soapstone, besides offering a low frictional resistance to pulling, has small need for a lubricant of any kind.

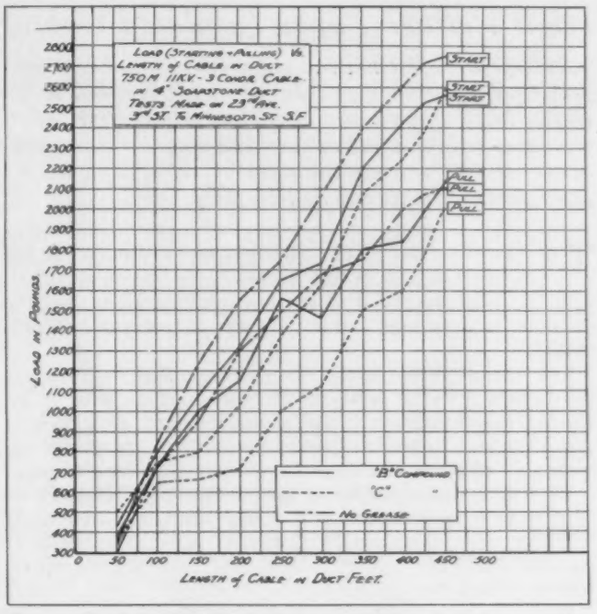


*Fig. 6. Similar tests in soapstone duct.*

### Conclusions

While it is not intended to establish with any finality the comparative merits of the several duct materials by means of the tests just outlined, nevertheless, a study of these tests has led to a few general conclusions, which are presented briefly as follows:

*Soapstone (standard type)—*

It is light in weight. Offers low frictional resistance to cable pulling. Surface is smooth, causing no abrasion to lead. Is not affected by service conditions. Withstands well the damaging action of an arc, since the slag is rather soft and easily cleaned out. Can be sawed as readily as fiber. It has slightly less strength than concrete, but can be readily shipped in car load lots and shows little breakage in hand-

ling. Some breakage in storage was experienced at one time, due to development of internal stresses from shrinking or from faults of manufacture, but improvements have been made and no doubt in time this fault will be eliminated entirely. The cost compares with other types.

*Soapstone—Asbestos Fiber—*

Practically the same characteristics as standard soapstone. While it is doubtful if there is much advantage in use of asbestos, it may offer some resistance to cracking by aging. The slag resulting from an arc is harder to clean out.

*Concrete (San Jose Type)—*

Is very good material and although heavier than other material, it can be shipped in carload lots with little breakage. Will stand rougher handling than will soapstone. The cost is reasonable. The surface is abrasive to cable sheath, and as a consequence the force required to pull in cable is high. Slag resulting from an arc is very brittle and is difficult to remove.

*Fiber—*

It is light in weight, is strong, is easily handled and reacts favorably to chemical action. Reacts unfavorably to heat and also to an arc. Offers high frictional resistance to cable pulling, and is affected more or less unfavorably by moisture.

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# *High Voltage Paper Insulated Cable**

*This paper is intended to point out some of the basic principles in determining whether or not it would be advisable to go to the higher operating voltages for underground distribution and outlines the progress made within the last few years in the manufacture of high tension paper insulated cable and its reliability.*

THE Pacific Coast, and California in particular, has led the world in high voltage transmission line development. This has been the result of necessity, by reason of the long distances to be covered and large blocks of power to be transmitted.

The fact, as shown in the recent census, that California is the fastest growing state in the union brings with it increased responsibilities to the power company engineers, in that they will, in years to come, have to provide almost unbelievable amounts of energy for densely populated areas.

With land values increasing and the good will of the public playing a more important role each year, it is very likely that the power companies will wish to place many miles of high tension transmission lines and of high voltage distribution systems underground.

When the time comes, and it may be nearer than any of us expect, suitable cables will be available to meet this economic necessity, as during the past eight years tremendous strides have been made by the leading cable manufacturers in improving their product, with the result that there are at the present moment in dependable operation in the United States many miles of 66-kv. solid type insulation and 132-kv. oil filled cable.

For 132-kv. installations we recommend only oil-filled cable. This requires the use of considerable associated apparatus and is economical only when comparatively large amounts of energy have to be transmitted, say 100,000 kva. and over.

Our studies indicate that 66-kv. solid insulation, which does not require any great amount of accessories, is most economical for loads of from 40,000 to 80,000 kva. Oil-filled 66-kv. cable fits in very nicely for loads of 80,000 to 120,000 kva.

In this paper we are confining ourselves very largely to 66-kv. cable.

## Salient Features in Design, Installation and Operation of 66-Kv. Cable

In considering a proposed installation of 66-kv. cable, we must first investigate the different types of cable available for this service. We must weigh their operating records, extending over a period of years, and study the economics of each type from the standpoint of present and future load requirements. Only after such an analysis has proven itself, are we justified in proceeding.

There are four types of cable available for 66-kv. service:

1. Single-conductor (solid type).
2. Single-conductor (oil filled).
3. Three-conductor (oil filled).
4. Three-conductor (solid type).

## Comparison of Types for a Specific Load

Assuming a 126,000-kva. load to be transmitted, we should require two separate circuits of six single-conductor cables or three separate circuits of three-conductor cable. If single-conductor solid type is used, each of the cables will be 750,000 circ.mil and each insulated lead-covered cable will measure 3 in. in diameter. If single-conductor oil-filled cable is used, each conductor will be 480,000 circ.mil and each cable will measure 2.15 in. in diameter. In the three-conductor oil-filled cable, each conductor would be 400,000 circ.mil and each of the three cables would measure 3.75 in. in diameter, which is close to the present practical manufacturing limits.

In the case of oil-filled cable, the thickness of paper insulation required is approximately half that used with solid insulation. In the particular case under consideration, it would not be feasible to use three-conductor solid type 66-kv. insulation for the reason that 400,000-circ.mil conductor with the requisite amount of insulation would result in a cable having an overall diameter of about 5.5 in., which at the present time is entirely too large from the standpoint of either manufacture or installation.

### Copper Economy for 126,000 Kva. at 66 Kv.

Single-conductor oil-filled 6 x 480,000 circ.mil or 2,880,000 circ.mil.
Three-conductor oil-filled 9 x 400,000 circ.mil. or 3,600,000 circ.mil.
Single-conductor solid 6 x 750,000 circ.mil or 4,500,000 circ.mil.

Copper economy, however, when comparing oil-filled cable with solid type, is not necessarily the determining factor, since at present the cost of accessories, when oil-filled cable is used, offsets the copper economy, except where the block of power to be transmitted is large. This is due to the fact that the cost of accessories as well as the cost of ducts, manholes, joints and installation remains practically constant regardless of the size of conductor.

## Dependability in Service of the Several Types

Single-conductor 66-kv. solid cable, the name being used to distinguish it from oil-filled cable, has an operating record extending over six years, so there is no question concerning the service to be expected from such cable. Single-conductor 66-kv. oil-filled cable has not been installed or operated to date in this country, but considering that this type of insulation is used on 132-kv. cable and has given an operating record of over a three-year period without a single operating failure, there is no question concerning its reliability for 66-kv. service. The quality of oil-filled insulation is clearly demonstrated by the fact that for 132-kv. operation 23/32-in. wall is used, whereas for solid type of 66-kv. cable the minimum insulation used in this country is 24/32 in. The maximum allowable operating temperature for 66-kv. oil-filled cable is 70 deg. C., for solid type, 60 deg. C. This

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* Prepared by O. R. Grant for the underground systems committee, Engineering Section.

allows the oil-filled cable to carry approximately 12 per cent more current for the same size conductor.

### Economics

Each type of cable has a certain field depending on its economics, for the particular load requirements, as well as its ability to meet future demands. The question of reliability or continuity of service may also play an important part in determining just which type is selected. Since three kinds of cable are available, the problem confronting the engineer is to decide which will be the most economical for his system. To do this, it is necessary to determine the capital cost for cable, ducts, manholes, accessories, repaving and installation. With this investment value and the kva. delivered by the particular size conductor selected, we can figure the cable cost per kva. per thousand feet, and use this as our index of comparison as far as installation cost is concerned. There are, however, other problems, such as transformer equipment and so forth, which may or may not have to be purchased, and these may change the decision as far as the cable is concerned. Fig. No. 1 shows the cost per kva. per thousand feet for solid and oil-filled cable at various voltages and loads. The cost includes cable and accessories, ducts, manholes and repaving. It is based on average labor and material costs in districts surrounding New York City. The annual cost is omitted. These curves show that there is a certain economical load range for each voltage and type of cable. 66-kv. solid type is most economical for loads from 40,000 to 80,000 kva.; 66-kv. oil-filled from 80,000 to 120,000 kva. From 120,000 to approximately 160,000 kva., 132-kv. oil-filled cable is the cheapest. Above 160,000 kva. 220-kv. cable will prove more satisfactory if and when it is proven commercially possible. These costs have been figured on the basis of one circuit in a 2 x 2-duct bank. This provides no spare circuit and the question of continuity of service must be given consideration.

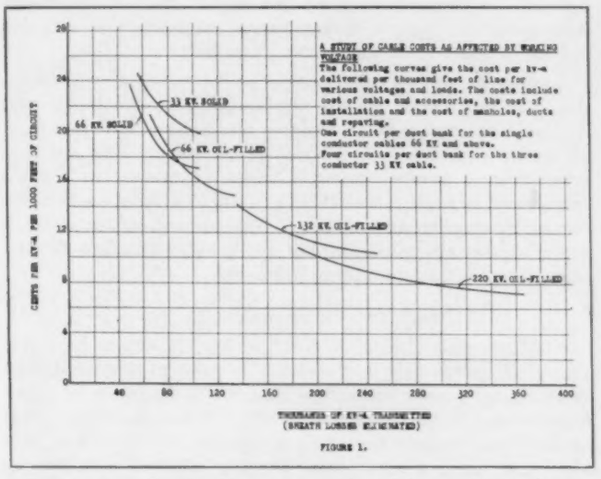
A STUDY OF CABLE COSTS AS AFFECTED BY WORKING VOLTAGE
The following curves give the cost per kv-a delivered per thousand feet of line for various voltages and loads. The costs include cost of cable and accessories, the cost of installation and the cost of manholes, ducts and repaving.
One circuit per duct bank for the single conductor cables 66 KV and above.
Four circuits per duct bank for the three conductor 33 KV cable.
33 KV SOLID
66 KV SOLID
66 KV OIL-FILLED
132 KV OIL-FILLED
220 KV OIL-FILLED
COSTS PER KV-A PER 1000 FEET OF CIRCUIT
0
4
8
12
16
20
24
28
40
80
120
160
200
240
280
320
360
400
THOUSANDS OF KV-A TRANSMITTED
(BREATH LOSSES ELIMINATED)
FIGURE 1.

*Fig. 1. A study of cable costs as affected by working voltage.*

The question of reliability may, for certain loads, make it advisable to install several 33-kv. or several three-conductor 66-kv. cables for total requirements, so that, in the event of a failure, a smaller percentage of the capacity is lost until service can be restored. No hard and fast rules can be given and the solution of each particular problem must be worked out separately.

### Operating Record on Solid Insulation Cable

Up to October 1st, 1929, the Associated Edison Illuminating Company's report shows three companies operating a total of 228.2 mi. of single-conductor solid type cable. The first installation was made by the Cleveland Electric Illuminating Company in 1924, at which time they installed 50 miles of 66-kv. cable. It is interesting to note that this was at that time the highest voltage underground cable in the world. Considering that fact that this was a pioneer installation and required cable and joints for a voltage which had never before been attempted, the success was remarkable, considering the state of the art at that time. Since then, up to August 1st, 1929, the Philadelphia Electric Company and the Commonwealth Edison Company have installed and operated 93.4 and 152.8 mi. respectively.

The Cleveland 1924 cable was insulated with 30/32-in. saturated paper, the Philadelphia Electric cable in 1926 was supplied with 30/32-in. and later installations have 26/32-in. The Commonwealth Edison Company is standardizing on 24/32-in. All these lines are giving very satisfactory service and the quality of cable produced is being steadily improved over that manufactured in 1924. The greatest improvement in the manufacture and installation of 66-kv. cable took place in 1928. This is indicated by the drop in operating failures for the first and second years of operation in cable of 1927 and 1928 manufacture. This improvement is the result of improvements in factory machines, intensive research on materials and processes and their better control, and has resulted in the dielectric strength test being increased approximately 100 per cent in volts per mil equivalent life for one hour, between cable manufactured in 1926 and 1929. The ionization or increase in power factor between 20 and 100 volts per mil also shows a considerable drop. This is a measure of the voids or air spaces in the cable—in other words, a measure of the thoroughness of evacuation and impregnation processes.

In 1924 1 per cent was considered a fair value, whereas in 1929 cables 0.05 per cent was the average. The failure records show that today's 66-kv. cable is more reliable than lower voltage cable as brought out in the N.E.L.A. operating report for 1929, which covers 422.5 mi. of 66-kv. cable. It shows 4.26 failures per 100 mi. of 66-kv. cable, as compared with 7.62 failures per 100 mi. on the lower voltage belted cable. Joints are also more reliable, as the joint failures reported for 1929 show 0.6 per 1,000 joints on 66-kv. cable, as against 3.3 per 1,000 on shielded three-conductor and 13.8 on belted three-conductor, operating from 20-kv. to 33-kv. This proves beyond a doubt that single-conductor 66-kv. is one of the most reliable solid type cables that is manufactured or in operation.

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## *The New Era in Rubber Insulation**

*Modern tests of rubber insulation for performance rather than appearance indicate the A.S.T.M. formula, once of great service, is now antiquated and that an insulation chosen on a different basis can be purchased for the same money, which will show as good, if not better, electrical qualities and will insure continuous service by satisfactory aging.*

IN COMMON with other products requiring engineering and technical work, rubber covered cable has been progressing with this age of improvements. The technology of rubber was slow in developing compared to many other lines, but in the past ten years its advancement has been outstanding. The application of this new knowledge to rubber insulation introduces a new era in the manufacture of rubber insulated cable, but very little has been published on this subject. Of particular interest is the work that has been done on "intermediate" and "30 per cent" insulation.

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* Written by G. P. Mackenzie for the underground systems committee, Engineering Section.

As representative of the whole subject of rubber insulation, we will confine our remarks to the latter.

### Old and Modern Specifications for Quality

The old standard method of specifying quality was to call for "30 per cent A.S.T.M." insulation. The purpose of this specification was to limit the manufacturer to good material and to furnish the consumer an easy means of checking the the make-up of the rubber compound. It did not allow the compound to contain reclaimed rubber tars, pitches, etc., the use of which was considered poor practice at that time. However, during the past few years great strides have been made in rubber chemistry and a number of new materials offered to the industry, including organic accelerators of vulcanization, and antioxidants. The use of these chemicals imparts very desirable qualities to the product, in that they provide the type of cure desired and give it longer life. Good electrical insulation should possess a right cure, which can readily be imparted by means of the proper organic accelerator. The A.S.T.M. specification was written before the advent of these materials and naturally did not make provision for their use. A compound containing these materials will not meet the A.S.T.M. specifications, as unfortunately the materials which have been found to be suitable for rubber insulation are somewhat soluble in acetone, imparting thereto a dark color, which does not comply with the specification's requirement of a light straw color of the acetone extract. The A.S.T.M. committee is now working on a revision of the specifications to permit the use of these very desirable materials and, in the meantime, search is being made to discover an accelerator and antioxidant which are suitable for the purpose and are less soluble in acetone.

These new 30 per cent insulations are called "performance compounds" because, instead of limiting the manufacturer along physical and chemical lines, stress is placed on the performance of the insulation during its useful life in actual service. What does it matter what materials the manufacturer puts in his compound, so long as they provide good electrical qualities and slow aging of the rubber insulation? Fundamentally, good electrical qualities are obtained in any rubber insulation by thorough dispersion of all the mineral pigments in the rubber compound and by using an accelerator which will give a tight and homogeneous cure in steam.

### Geer Test

The relative valuation of antioxidants in the aging of rubber stock is determined by two important laboratory aging tests, known as the "Geer test" and the "Bierer-Davis oxygen bomb test." In the former, a continuous supply of fresh air, heated to a temperature of 150 deg. F., is blown into an oven containing standard test strips of the material to be tested. The strips are suspended from a wire passing through a hole in one end and are separated by rubber discs, permitting a free circulation of air and exposure of the entire surface. The test is continued for about two weeks, and each day two samples are taken out, which are allowed to stand for 24 hours at room temperature, after which they are tested for tensile strength and elongation.

In natural aging, the acetone of a rubber compound increases as the life of the compound progresses, due to the fact that the rubber hydrocarbon oxidation is converted into resin which is soluble in acetone. The Geer test does not show this phenomenon, and thus, many authorities feel that it does not subject the rubber to a true aging action. There are other physical evidences that this test does not duplicate the natural aging process, as it does not produce the soft and tacky condition nor the hard brittle condition that some compounds acquire on aging, and sometimes it does not deteriorate stocks which age poorly under natural conditions. On the other hand, some stocks with good aging qualities deteriorate rapidly in the Geer oven. The deterioration of rubber is now recognized to be due chiefly to oxidation and the shortcomings of the Geer test are due to the emphasis it places on heat rather than oxygen.

### Oxygen Bomb Test

These facts led to the development by Bierer and Davis of a test known as the "Bierer-Davis oxygen bomb test." Standard test strips are placed in a special bomb, which is charged with oxygen at a pressure of 300 lb. per sq.in. and maintained at a constant temperaturet of 60 deg. C. The procedure is very simple and the necessary equipment may be installed at a cost which is very small, compared to the value of the results obtained in determining the aging properties of rubber compounds. By this means deterioration practically identical with several years of natural aging can be brought about in a few hours, and not only have the widely different phenomena observed with rubber compounds containing very low or very high amounts of free sulphur been duplicated for the first time, but also the actual behavior of rubber in the presence of dry or moist air, in the presence of antioxidants, and in the presence of oxidizing agents such as manganese and copper compounds. Chemical analysis of the rubber after such oxidation indicates that the deterioration is similar to that of natural aging. In each case, for instance, the acetone extract is an index of the extent of the deterioration. With this method, systematic investigations can be made of the influence on aging of various accelerators, different types of rubber, shoddies, softeners, antioxidants, and all the various classes of rubber ingredients.

### Causes of Deterioration

While the reactions which occur when rubber deteriorates are not yet well understood, it is generally recognized that the most important contributing factors are light, heat, and oxygen. If, then, vulcanized rubber could be protected from all three of these influences, its life would be greatly prolonged. It can be protected from light by storage in darkness and to some extent by proper compounding, and it can be made resistant to heat by the use of special compounds. Atmospheric oxygen is in many cases the most serious factor, but fortunately it is the easiest to combat.

Until quite recently the most effective means of preventing the deterioration of rubber compounds from oxidation was the judicious choice of an organic accelerator and the use of all active ingredients in the best proportions. Now we have substances of a new character called "antioxidants," which far exceed organic accelerators in their ability to improve the aging quality of vulcanized rubber and which allow a much greater margin of safety and greater freedom in compounding and manufacturing processes.

### Development of Antioxidants

While the mechanism of their protective action is still a matter of speculation, antioxidants in general are substances which under proper conditions retard the oxidation of much larger amounts of other substances. Since, however, some accelerators improve the aging properties of vulcanized rubbers, and some antioxidants have a distinct accelerating action, it is impractical to draw a sharp distinction between accelerators and antioxidants. Obviously in many cases, they have certain properties in common and, therefore, must be judged on a basis of predominant characteristics. Although the influence of antioxidants on the rubber, and the development of new antioxidants for rubber, are being investigated chiefly within the rubber industry, the impetus for this development can be traced back to the work of Moureu at the College de France. In a series of masterly researches, he has shown that many compounds, even when present in extremely small amounts, inhibit the oxidation of many organic substances, including numerous simple compounds, as well as all resins, rubbers, etc. These essentially academic researches of Moureu, which nevertheless led him to obtain patents for retarding oxidation of all resins, rubbers, etc., have been ac-

companied by an intensive search within the rubber industry for substances having a specific antioxidant action on vulcanized rubber. This is a striking example of that prompt utilization and commercial application of what was at first organic chemical research of an academic type. At present intensive research is being carried on to find more powerful antioxidants among compounds already known and to synthesize new compounds of greater antioxidant power. Several substances have already obtained commercial importance and the use of antioxidant has grown so rapidly that already several hundred tons are used each month in the United States alone. It is interesting to know that natural antioxidants have been discovered in crude rubber and have been successfully isolated and characterized in an empirical way, and it is not too much to hope that, when they are eventually identified, they will serve as a basis for the synthesis of antioxidants of tremendous power.

### Natural Antioxidants

These natural antioxidants are the only protection which the rubber possesses against rapid deterioration and, if they are removed from the rubber before it is compounded and cured, the resulting vulcanizate deteriorates very rapidly. Antioxidants have already come to rank in importance with accelerators and other important compounding ingredients as indispensable agents in modern formulations. It is in many rubber products, which deteriorate primarily because of oxidation, and which would remain in service longer if they aged better, that antioxidants are of immense value, and they should be regarded by the progressive manufacturers not only as a valuable means of insurance against bad aging, but as an indispensable agent in an effort to improve the quality of his product. As more and more powerful antioxidants are developed, we will be able to produce goods of all kinds which will no longer deteriorate appreciably when in service and which will thus enable the consumer to benefit directly by this fundamental improvement in the art of rubber manufacture.

### Comparative Rate of Cure

With this description of organic accelerators and antioxidants and accelerated aging tests as a background, we are now prepared to show a few figures representing actual data found on "30 per cent A.S.T.M." and the new "30 per cent performance" insulation.

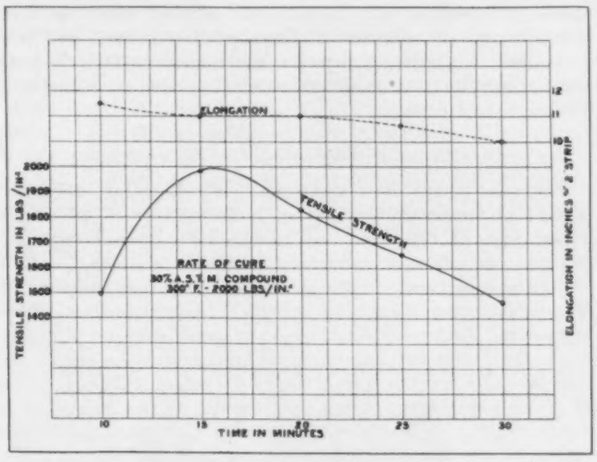


*Fig. 1. Rate of cure of "30 per cent A.S.T.M." compound.*

Since it was pointed out previously that a decided overcure or under-cure seriously affects the aging qualities of a compound and since it must be born in mind that decided over-cure or under-cures will seriously affect the electrical qualities of an insulation, Figs. 1 and 2, showing the rate of cure of "30 per cent A.S.T.M." and "30 per cent performance" compound, respectively, will be of interest. It will be noted that the tendency of the A.S.T.M. compound for overcures, with a pronounced drop in tensile strength and elongation, is very marked, whereas the 30 per cent performance compound, properly blended with correct organic accelerators and antioxidant and other necessary compounding ingredients, which it would be impossible to use under the

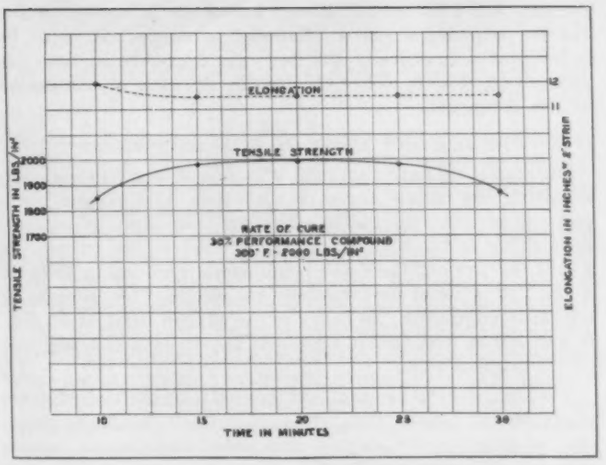


*Fig. 2. Rate of cure of "30 per cent performance" compound.*

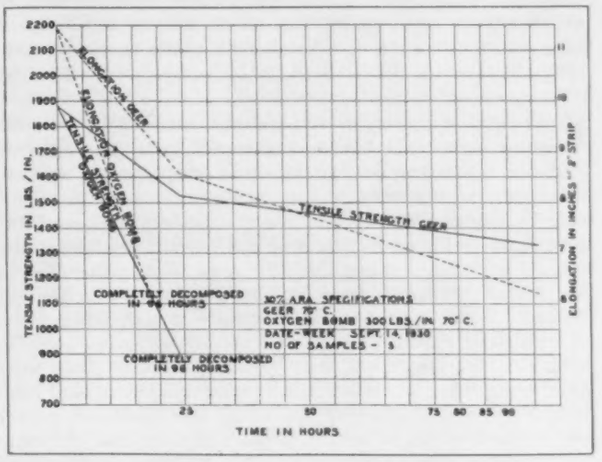
ELONGATION GEER
TENSILE STRENGTH GEER
COMPLETELY DECOMPOSED IN 96 HOURS
30% ARA SPECIFICATIONS
GEER 70° C.
OXYGEN BOMB 300 LBS./IN. 70° C.
DATE-WEEK SEPT. 14, 1930
NO. OF SAMPLES - 5
COMPLETELY DECOMPOSED IN 96 HOURS
TENSILE STRENGTH IN LBS./IN.
ELONGATION IN INCHES ON 2" STRIP
TIME IN HOURS

*Fig. 3. Tensile and elongation characteristics—Geer and oxygen bomb tests—"30 per cent A.R.A." specifications.*

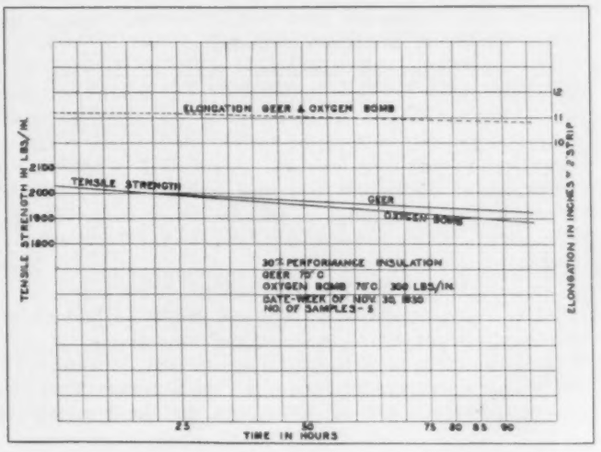


*Fig. 4. Tensile and elongation characteristics—Geer and oxygen bomb tests—"30 per cent performance" insulation.*

present A.S.T.M. specifications, has what is known to the rubber technologist, as a "flat curing curve." It is to be noted that a practically 100 per cent over-cure in time affects little, if any, either the tensile strength or elongation of the compound.

### Tensile and Elongation Characteristics

On Fig. 3, we have curves of a standard specification, representing the tensile curve in both Geer and oxygen bomb test and also the elongation curve for both types of accelerated aging tests. Note the sharp decline in the curves. In Fig. 4, we present Geer and bomb accelerated aging tests of a new "30 per cent performance" insulation. The decrease in tensile strength after 96 hours in the oxygen bomb at 70 deg. C. and 300 lb. pressure of oxygen is approximately 5 per cent of the original tests.

The only conclusion that can possibly be arrived at from experimental data of this type is that the A.S.T.M. formula, once of great service, is now antiquated and that an insulation can be purchased for the same money which will give as good a test, if not better, for electrical qualities and at the same time will insure continuous and faithful service by good aging, and which represents all that any vendor or buyer of cable would be interested in—namely, performance.

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## *High Voltage Rubber Cables**

*The field for rubber insulation for submarine use, in aerial cables and for vertical risers in tall buildings is here presented in comparison with other types of insulation.*

IT IS quite surprising to observe that, considering the number of years that rubber compounds have been used as electrical insulation, we find their field of application confined principally to low voltaegs, say, 2,300 volts and less. This may be explained in several ways. Rubber insulation was used early in the development of the electrical industry, and when low voltages were the only ones used. The idea of low voltage seems to have become associated with that of rubber. When higher voltages came into use, other types of insulation were used and not sufficient attention given to rubber. This may have been justified, because there were only two grades of rubber insulation available, a code compound, which is very cheap due to the low quality of rubber and methods of manufacture of the compound and the insulating of the wire or cable; the other a compound known as "30 per cent," due to its having 30 per cent by weight of new rubber in it. Very few manufacturers were capable of making such a compound and being rather expensive, it was not used unless the conditions of service required the highest quality of insulation obtainable.

It is only within the last fifteen years at the most that rubber insulation has been considered for high voltage operation. This has been brought about by the demands of industry for the transmission of power, which requires taking advantage of the physical and mechanical properties of rubber, aside from the electrical properties. Wherever rubber insulation is used, it will be found that it is not desirable or feasible to use either paper or varnished cambric cables.

### Comparison of Insulation Types

Let us compare the three types of insulation in common use for their respective physical and electrical properties. Rubber insulation is quite elastic or resilient, is waterproof and is a homogeneous mixture of all the ingredients used in its composition; it can be easily bent without breaking; it has a very low thermal coefficient of expansion, and, therefore, when heated has practically no volumetric expansion; has no physical ingredient mixed with it that in time will separate out, and so may be considered as a permanent material; it can be applied to a wire or cable and after vulcanization is ready to use, if desired, or may have a protective covering. Electrically it has very good dielectric strength and high insulation resistance. It has a reasonable power factor value, practically independent of temperature; this is lower than the power factor for varnished cambric, but higher than impregnated paper as used today. It has the undesirable feature that, if stressed high enough electrically in the presence of air or oxygen, it will cut, which we call "corona cutting."

Varnished cambric insulation consists in wrapping a varnished cloth in tape form on a wire or cable and applying a slipper compound between the tapes. It is necessary to use a braid or lead sheath overall. It is not waterproof and, therefore, should not be used in the presence of moisture; it can be bent fairly sharply; it has a good dielectric strength (better, if it were possible to exclude air and moisture, which is difficult on account of the method of manufacture); it has a high power factor and, therefore, high dielectric loss; it can be operated at higher temperatures than rubber insulation, although not as high as impregnated paper. It is limited in its voltage application to about 19 kv., although a few higher voltage cables are in operation. Its main faults are high dielectric loss and non-moisture properties.

Impregnated paper insulation consists of paper tapes wrapped on a wire or cable and then impregnated with an oil to give the paper its electrical properties. It cannot be bent sharply or the paper tape will tear; it can be operated at higher temperatures than either rubber or varnished cambric; it must be protected by a lead sheath or the oil will quickly drain from the paper, and it easily absorbs moisture if not protected. It has very good electrical properties, very high dielectric strength and low power factor and dielectric loss. It can be used at any voltage in use today. Its advantages are the necessity of using a lead sheath, which in some conditions of operation, such as vibration, may become crystallized and crack. If the lead sheath is damaged in any way, moisture will work in and oil leak out and the cable is on the way to failure. Oil has a high coefficient of thermal expansion, which is undesirable, as on the heating up of a cable, the amount of volumetric expansion of the oil may cause the lead sheath to expand, causing voids to form when the cable cools down. So-called "ionization" will take place, which gradually weakens the insulation and, in time, failure results. If installed vertically, the oil will easily drain to the bottom.

### Submarine Cables

From the above, it is apparent that rubber insulation has a field of application on low or high voltages in which the other types of insulation are excluded for some mechanical reason—for example, wherever vibration will exist, where moisture is present or where oil drainage may take place. The actual types of service in which these conditions either separately, by two or all three exist, are: submarine cables, aerial lines and vertical risers. Where submarine cables are used, we have moisture conditions—therefore, rubber is ideal. It is not necessary to use a lead sheath, as the insulation is waterproof. If a lead sheath is used and it breaks, water will enter, but no harm will be done. It is better not to use a lead sheath, as the water surrounding each conductor results in the single-conductor condition of a perfect grounding around each conductor, and also the heat conduction away from the insulation is greatly improved—both most desirable. The shore ends of a submarine cable ordinarily do not have the perfect grounding of the insulation nor the heat dissipation existing in the under-water section. As a result, special provision must be taken to correct these conditions

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* Written for the underground systems committee, Engineering Section, by R. J. Wiseman.

if we wish to load the cable up to the capacity possible on the under water section. This can be done by increasing the size of the conductor for the shore ends and by using special metal shielding of the conductors in order to produce the grounding existing on the under-water section.

In some submarine cable installations, tide conditions are such that a cable will be rolled back and forth. If a leaded cable is used, this will, in time, cause crystallization of the lead sheath and failure of the lead, allowing the water to enter. Naturally, this prevents the use of paper cables and rubber non-leaded cables are the only ones that should be used.

### Aerial Cables

All three kinds of insulation are used for aerial cables. If leaded cables are used, it is customary to use alloyed lead sheaths in order to retard crystallization. This means heavy cable, consequently the messenger wire carrying the cable must be designed to carry the load. Varnished cambric cables, with or without armor protection, can be used. Here again, alloy leaded cable can be used, but the cable is too heavy. If non-leaded, it should have armor protection and to make the cable moisture-proof, it should have, under the armor, a special protection such as a reinforced rubber belt or a very heavy well saturated weather-proof braid, the former being preferable. The simplest construction of all is rubber cable with an armor protection. Armor protection may be dispensed with if the cable is not liable to be damaged, if a heavy, well saturated weather-proof braid is used and, if the voltage is high enough to warrant it, by the use of corona shielding tapes over the insulation. In the field of aerial cable may be included lines carried on poles, bridges, elevated structures, railroad viaducts and trestles.

### In Tall Buildings

Within the last two years a new field of usefulness for rubber cables has been opened up by the new practice of bringing the high-voltage power supply in very tall buildings to a transformer vault on certain floors, where it is connected to low voltage for distribution as light and power. The type of vertical riser cable used in these buildings must be such that fire insurance requirements are met, so that no fire hazards will exist. This excludes the use of impregnated paper cables, due to the migration of the oil to the bottom and to the bursting of the lead sheath, and should exclude the use of varnished cambric cables, as the slipper compound will drain to the bottom and cause trouble. There are two types of insulation now being used for this service—the all-rubber cable and a composite cable consisting of a heavy wall of rubber insulation immediately over the conductor and a thin wall of varnished cambric tape over the rubber. This latter construction is better than either paper or varnished cambric, but not as good as an all-rubber cable. Its defect is in the space where the rubber and varnished cambric come in contact. Any entrapped air here will become ionized and in time, corona cutting of the rubber will take place.

### Use of Rubber With High Voltages

What kind of rubber insulation should be used for high voltage cables and how high can we go in voltage? Under no condition should code compound be used. It does not possess any property that warrants its use. For single-conductor cables, metal shielded, such as with a lead sheath or a metal tape, or non-shielded and immersed in water, some "30 per cent" rubber compounds can be used up to 7,500 volts to ground. If non-shielded and used in a dry state, some "30 per cent" rubber compounds up to 4,000 volts can be used, if proper means are taken to protect the rubber from the air. For multiple-conductor cables used in the dry state, that is, no shielding and not in water, some "30 per cent" rubber compounds can be used up to about 7,500 volts, three-phase.

If each conductor is shielded, either with a lead sheath or metal tape or the cable is immersed in water, which surrounds each conductor, some "30 per cent" rubber compounds can be used up to 15,000 volts. three-phase.

The limiting voltage for a "30 per cent" rubber compound depends upon the voltage at which corona will start at the surface of the insulation. If we could be certain about getting perfect grounding contact over every particle of surface of the insulation, we could operate the cable to higher voltages than given above. Unfortunately, such is not the case. What are the factors causing this limitation? The dielectric strength of rubber insulation is ample for all practical purposes—therefore, this property is not involved. The specific inductive capacity and the resistance to corona are the two factors to be considered. Corona will take place wherever air is present and is stressed electrically to a point where it breaks down and forms ozone. Ozone attacks rubber very easily. Rubber can be attacked by ozone without having any voltage stress on the rubber insulation. The voltage stress at which corona takes place is a function of the specific inductive capacity, S.I.C., of the insulation. The lower the S.I.C. the higher the voltage necessary to produce corona; therefore, in general, a compound having a low S.I.C. is preferable to one having a high S.I.C. However, different compounds have different degrees of resistance to corona. It is possible to have a low S.I.C. compound, yet it may not be highly resistant to corona and it is no better than a compound having a higher S.I.C. Recently there has been placed on the market a low S.I.C. compound and it has been stated that it is ideally suited to high voltage conditions. From information gathered, its corona resistant properties are not as good as desired. Even though theoretically no ozone should form, there may be end conditions where ozone is present. Under these conditions it is essential to have a compound which is resistant to ozone, as well as having low S.I.C.

There is a compound on the market which has both a low S.I.C. and high corona resistance. This compound has been tested in use for several years. It is of special composition, requiring very exacting handling in the factory, but well worth it, in view of its applicability. In the single conductor dry state and non-shielded, it can be used up to 7,500 volts to ground; for higher voltages it should be lead-covered or metal-shielded. For multiple-conductor, non-shielded cables, it can be used in the dry state up to 15,000 volts, three-phase. For higher voltages a metallic shield over the insulation on each conductor is recommended up to 33 kv., three-phase. As it is necessary to have a very high factor of safety on vertical riser cables, this special compound is recommended with metallic shielding, even for 12 kv., although it can be used without metallic shielding. For submarine cable, it may be used non-shielded up to about 19 kv., above which metallic shielding is recommended.

We more clearly understand today what are the essential properties of rubber as an insulation and we are beginning to realize more than ever that rubber has a field of application on high voltages which makes it worthwhile for the cable manufacturer to carry on researches on rubber and for the user to consider very seriously some of the conditions existing on his lines, either new lines where trouble is liable to happen due to some of the conditions cited above, or where troubles have already developed on some installations.

# Insurance Committee Report*

*The insurance committee has constituted itself a service bureau on matters pertaining to insurance for the benefit of member companies. Here are reported changes in local laws or movements which may affect the insurance situation on the Pacific Coast.*

THE general policy of avoiding duplication of effort by not undertaking investigation of insurance problems being examined by the national committee has been observed during the past year. No problems peculiar to the Pacific Coast have developed of sufficient importance to warrant a general meeting of the committee, but an informal meeting was held in the office of the Southern California Edison Company Ltd. to discuss the scope of our annual report. The following subjects are considered of interest to the membership:

### Automobile Public Liability and Property Damage Insurance

Very heavy increases in automobile public liability rates became effective on Feb. 1, 1930, for all new business and all renewal business. For the inland territory, California, the increases range from 20 per cent to 35 per cent, depending on the class of car—that is, "passenger" or "commercial," and also, on the individual make of equipment. In the metropolitan area of Los Angeles and in the San Francisco Bay district, the increases were much heavier than for the outlying territories. The reason generally assigned for the higher rates is the tendency of the courts toward higher damage verdicts, especially in cases where the defendant is a large corporation, or public utility. This condition accentuates the importance of member companies giving consideration to the adequacy of the limits in their insurance policy. Many of the companies now carry public liability limits of $50,000 to $100,000. The additional premium for the higher limits is relatively small and the additional protection is advisable.

A change has been made in the manual with respect to the minimum age limits of drivers, the new rule excluding vehicles while being operated by any person under the age limit fixed by law, or under the age of fourteen years in any event, instead of the previous limit of 16 years. Since California grants an operator's license to persons 14 years of age, it is important to see that the printed portion of a policy reading otherwise is changed by indorsement.

### Workmen's Compensation Insurance

The California Self-Insurers' Association, with headquarters in the Sheldon Building, San Francisco, is distributing valuable bulletins concerning decisions of the California Industrial Accident Commission and of the courts, interpreting the compensation act. The association evidently is watching legislative matters and advising its members with respect to proposed changes in the compensation act which are considered important. The power companies of California are not affiliated with this organization, but representatives of several of the companies attend the meetings by invitation and keep in touch in a general way with the activities of the association.

### Coverage on Fluctuating Stocks of Merchandise

The national committee has given some consideration to a form of fire insurance coverage on fluctuating stocks of material and supplies, appliance merchandising stores, etc., where the values are subject to pronounced increases or decreases of a seasonable nature, or in accordance with operating conditions. A form for such insurance has been worked out by the Interstate Underwriters Board, having head offices at 135 Williams Street, New York. The main characteristics of these new forms, intended to supercede the Inland Marine Floater policy, are as follows:

Form No. 1—Monthly Average. This form covers property in stores, warehouses or distribution points. It requires a report of values as of the last day of each month during the policy year. It covers merchandise, supplies, furniture and fixtures.

Form No. 2—Daily Average. This form covers stock, furniture and fixtures in manufacturing plants of a strictly seasonal nature, such as canneries, fertilizer factories, where there is a wide fluctuation in the value of the stock. A report is required once a month of the daily average values of the property covered.

Form No. 5—This is a non-reporting, co-insurance floater, similar to ordinary floaters, requiring 100 per cent co-insurance.

In all of these forms there is a state limit of liability at each location. In some territories, like New York City, the maximum limit of loss at any one location shall not be more than 35 per cent of the total estimated average annual values at all locations as shown in the application for this kind of insurance. This fact should be noted, because it means that the total of all values cannot always be covered under this form of insurance. Another fact to be noted is that this form is always excess insurance, that is, it does not contribute in any loss until any specific insurance in force is exhausted.

At the time the insurance is effected, a statement of average annual values at each location is required. Based on this, a provisional amount of insurance is established and premium paid.

While attention is called to the above form of insurance, the national committee has not definitely recommended it, feeling that an Inland Marine Floater policy is superior because it can be designed to meet the particular conditions surrounding the assureds' risk, the rate would probably be lower, being a matter of negotiation, and the co-insurance requirement would not be as rigid. These forms of coverage on fluctuating stocks are superior to the specific form of insurance, on account of the blanket feature, the flexibility of coverage at various locations and the provision for pro-rata computation of premiums on additions and cancellations.

### Third Party Liability Insurance

Your committee has had further correspondence with the national committee with respect to the subject of insurance against damage to the property of others, resulting from fire for which the assured may be legally liable. The committee suggests that member companies give consideration to this form of insurance. Thus far the rates have proved prohibitive, the premium being based upon gross earnings. Your committee has endeavored to find a market for some form of excess public liability insurance of this kind that could be obtained at a reasonable cost. This year the national committee appointed a subcommittee, charged with the duty of investigating this particular form of insurance, but thus far a report has not been rendered nor are there available any reports on this subject for previous years. It is hoped that a report will be forthcoming in the near future that will offer a practical solution of this problem.

### General

The fire insurance rate situation has remained practically unchanged during the past year. General economic condition has brought about a sharp competitive situation which has developed a disposition on the part of most of the companies to be more liberal.

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* Report of insurance committee, Herbert Dewes, The Southern Sierras Power Company, chairman. L. A. Reynolds, Pacific Gas and Electric Company, vice-chairman.
Arizona Power Company: A. C. Johnson.
Los Angeles Gas and Electric Corporation: F. E. Seaver.
Pacific Gas and Electric Company: R. J. Cantrell.
San Diego Consolidated Gas & Electric Company: H. R. Peckham.
San Joaquin Light & Power Corporation: W. E. Durfey.
Sierra Pacific Power Company: V. D. Armstrong.
Southern California Edison Company Ltd.: Clifton Peters.

# Public Relations Section[1]

## *Employees' Speaking Contest**

*Details of the employees' public speaking contest for* 1930-31 *are here outlined and a report of last year's contest is given, together with the winning speech.*

THE principal change in conducting the tryouts for the National Employees' Speaking Contest in the Pacific Coast geographic division this year was the formation of a special committee under the jurisdiction of the Public Relations Section to handle this work, instead of turning it over to the Advertising-Publicity Section as has been done in the past. Several modifications have been made in the contest this year by the national committee. Chief among these is the decision to hold separate contests for both men and women, with duplicate prizes for each group. This year all prizes are in cash, the first prize in the national contest being $1,000, the second $500, and the third $250. Duplicate prizes are offered for both men and women. A second change is the holding of a series of semi-finals for the purpose of selecting three contestants to appear on the program of the annual convention of the National Electric Light Association at Atlantic City. Thus, the winner from this geographic division will compete with winners from the Northwest, Rocky Mountain and Canadian divisions.

The subject for the 1930-31 contest was "The Contribution of Electric Service to American Home Life—and Its Future Possibilities." Practically the same rules as applied last year were set up for the contest this year.

In this division, duplicate prizes for both men and women were set up as follows: First prize, $100 in stock in any utility company of the winner's choosing; second prize, $30 cash; third prize, $20 cash.

The same method of conducting contests used last year was employed this year. Details of the contest were explained to all employees of member companies in the territory, by means of a four-page pamphlet compiled from information furnished by the National Public Speaking Committee. Twenty-five hundred copies of this pamphlet were distributed among member company employees. A record of the total number of employees interested in the contest was kept by means of registration certificates which an employee must sign before literature describing the contest was supplied to him. Contests were conducted progressively in this territory. Elimination contests within the member companies were used to select their representatives. Semi-finals were conducted in northern and southern California among company representatives. Semi-finals in Arizona were conducted at the Arizona Utilities' Association, Phoenix, April 8 to 11. Finals for this division to select a man and woman to represent the Pacific Coast Electrical Association at the national semi-finals at Salt Lake City were determined at a contest conducted in Fresno on May 8.

In order to bring the records of the association up to date as regards the year 1929-30, this report contains final facts relative to last year's contest. More than 200 employees of Class A member companies participated in the 1929-30 contest. In the various progressive steps of the contest these speakers addressed audiences totaling over 1,500 people. The following is a list of company winners in this division: L. D. Conard, electric department, Pacific Gas and Electric Company, Woodland; Alfred Shackelford, Tucson Gas, Electric Light & Power Company, Tucson; James B. Willey, San Diego Consolidated Gas and Electric Company, San Diego; Miss Marie Houlahan, Great Western Power Company of California, San Francisco; L. S. Peterman, Southern California Edison Company Ltd., Los Angeles; William M. Fisher, Los Angeles Gas and Electric Corporation, Los Angeles; J. C. Barrington, Coast Counties Gas & Electric Company, Santa Cruz; Garrett L. Van Buren, San Joaquin Light & Power Corporation, Fresno; and L. F. Hallet, The Southern Sierras Power Company, Riverside.

In the finals of this division, first place went to Mr. Conard, and second place to Mr. Shackelford. Mr. Conard represented this division in the national finals at the San Francisco convention of the National Electric Light Association, but he did not place among the first three winners in that contest. Mr. Conard's winning speech is attached to this report so that it may become a portion of the records of the association.

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## *The Electric Utilities' Contribution to My Community, State and Nation*[2]

THE early pioneers and settlers of America were circumscribed by their physical limitations. Therefore, a man's usefulness to his family and community depended largely on his own physical ability. Time was considered a copious quantity, darkness was accepted as an unavoidable ending to all human activity, any great distance represented days and weeks of arduous toil and hardships. Crude were the comforts and meager were the labor-saving devices which graced the homes or aided the activities of our ancestors. But they were not destined to live and labor in such homely environment. The dominant, pioneering, ambitious and progressive instinct which spurred them to leave unsatisfactory conditions in Europe now kept them relentlessly striving and seeking to better conditions in their new lives.

Across their limited horizon flashed that mysterious phenomenon, Electricity; in their eager hands was placed this wonderful instrument of progress. It would seem that Divine Providence had ordained that they were the chosen people who, by their inborn qualifications were elected to perfect and develop this marvelous miracle of efficiency and comfort that had lain dormant for countless ages.

From their ranks arose the famous wizard of Menlo Park, the mighty molder of our electric destiny, Thomas A. Edison. From his giant intellect came the inception of the incandescent light whose matchless brilliance was to illuminate the world, the electric motor which was to turn the wheels of progress and the central station which feeds the arteries of electric utilities' distribution. By his side walked Stanley of the transformer, Tesla of the induction motor, Westinghouse of the alternating current, and a great army of faithful workers that had followed them down through the years. For, ladies and gentlemen, if we are to consider electric utilities' contribution to our welfare and prosperity, we must first, in all fairness, pause and pay tribute to these men of vision, whose lifelong and undaunted devotion to experiment and research has made electric utilities possible.

From their master minds came the organization of our unequaled power systems which have glorified the timely slogan "Continuuous Courteous Service," and proved the virtue of the golden rule in business. Their untiring energy and engineering activities have

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[1] Executive committee—E. B. Criddle, chairman. Addison B. Day, vice-chairman. R. E. Fisher, W. L. Frost, F. L. Greenhouse, Mrs. Nyra G. Letchworth, D. L. Scott, G. C. Tenney.

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* Report of the committee on employees' speaking contest, Public Relations Section. G. C. Tenney, Electrical West, chairman. Richard Smith, Southern California Edison Company Ltd., vice-chairman, Mrs. Nyra G. Letchworth, San Joaquin Light & Power Corporation, vice-chairman.
Arizona Edison Company: Miss Wilma Jones.
Central Arizona Light & Power Company: A. F. Morairty.
Coast Counties Gas & Electric Company: Miss Alma Freeburg, Pierre Vinet.
Los Angeles Gas & Electric Corporation: Miss Marvel Murray, D. L. Scott.
Pacific Gas and Electric Company: Al C. Joy, W. A. Worthington.
San Diego Consolidated Gas & Electric Company: Miss Nell Molloy, F. M. Raymond.
San Joaquin Light & Power Corporation: Lloyd Henley, Miss Clyda Weems.
Sierra Pacific Power Company: O. S. Clifford.
Southern California Edison Company Ltd.: Mrs. Jeanette L. Reese.
The Southern Sierras Power Company: A. G. Cage, Miss Margaret Gabbie.

[2] Prize winning speech by L. D. Conard, electric department, Pacific Gas and Electric Company, Woodland, Calif.

fostered the expansion and development of electric utilities until in the short space of 45 years they stand on a pinnacle of achievement which is the pride of our nation and the envy of the civilized world.

The home is our nation's foundation. It is woman's domain, our children's environment and man's refuge. Here it is that electric utilities have brought myriads of blessings. We men of America have always glorified womanhood. Electric utilities have emancipated her from back-breaking, soul-dwarfing drudgery that for years has kept her confined to the four walls of a poorly equipped, half-lighted, inconvenient home. With the advent of electric cooking, heating, lighting, washing and refrigeration, she may move like a queen among her subjects, commanding a ready host of mechanical servants to perform her many duties at the press of a button; thus her time for household labors has been vastly minimized. With this new-born freedom and freshness of mind and body, she may adequately care for the health, education, discipline and private problems of her children, thereby insuring the best growth and development of character which is a priceless contribution to the welfare and happiness of future generations; to the leisure hours comes the radio, bringing the best in music, the finest in education and the cleanest in recreation and the crowning glory is that there are sixteen million homes now electrified in the United States with one and one quarter million being added yearly. Come, let us join our women folks in generous gratitude for the bountiful benefits which this superb gift of American science and inventive genius has contributed to our domestic tranquility through electric utility development.

Agriculture is the basis upon which rests our nation's prosperity. One hundred per cent of our foodstuffs come originally from the soil. During the past years, farming conditions in this country have been growing steadily worse; Congress has for months been floundering in a vain effort to create legislation that would relieve the situation. In the meantime, throughout the length and breadth of our land the copper highways of electric utilities have been patiently and persistently permeating every countryside, carrying as first aid to the farmer that excellent labor saver, Electricity.

The farms of our fathers were heart-breaking places of endless toil and discomfort. Inefficient methods of operation created long hours of labor, leaving no time for recreation or social pleasures. The early life on a farm was, indeed, a drab and lonely existence. But by the dependable and economical flow of the magic kilowatts, the old-fashioned farm has been miraculously transformed into a smooth-working, industrial institution. At the snap of a switch the cows are milked and feed is ground; by the automatic control of light in the hen house, biddy's winter day is lengthened with increased egg production; a network of water pipes is kept constantly supplied by an automatic pressure system and in the field stands the pumping plant ready to supply moisture at will, making a crop failure from this source impossible. The squatty farm house is fast giving way to a brilliantly lighted country mansion enjoying every convenience of a city dwelling. Gone is the much cartooned, horny-handed "rube" farmer. In his place stands a clear-eyed, intelligent, up-to-the-minute country gentleman. The grandmother of that smart looking lady you may see alighting from her up-to-date car in any shopping district probably wore herself into an early grave working a pump handle or sweating over a washboard. But her granddaughter belongs to a new era. Electric utilities have eradicated her drudgery and modernized her home until she can take her place in the community of life with any of her city sisters. Congress may legislate and experts cudgel their brains for a means to financial farm relief but, ladies and gentlemen, consider this—farms are being abandoned because of intolerable living and working conditions. Whatever is done, the farmer must be kept upon the farm for, although we could dispense with many of the luxuries, this indisputable fact remains—our nation must eat! Quick relief for the situation is sorely needed and electric utilities are playing a tremendously important part in supplying it. And, again, we are gratified to learn that in 1929 there were over 600,000 farms in the United States being electrified by some distant waterfall or steam turbine.

Electric utilities have been most lavish in their contributions to the progress of our nation's industry. Until about ten years ago, industry, in order to find the best labor, power and market conditions, was forced to concentrate in the larger cities. This had resulted in higher taxes, higher costs and increasingly miserable housing and living conditions for their workers. But the beckoning voice of electric utilities invited the fast expanding industries to come to the country. "Come where land values and taxes are more reasonable, come where your workers will be able to establish more comfortable and healthful homes of their own, come where there is an abundance of constant and cheaper power for your every need." And industry has widely heeded this call. Where the benevolent army of kilowatts has led the way, industry has followed. For example: The Southern states are fast becoming an agricultural empire, for the main reason that they are also becoming an industrial empire. From 1890 to 1923, the manufacturing and agricultural wealth of the South increased from six and one-fourth to twenty-eight billions. This was brought about by the development of water power and the widespread distribution of electric energy. The result has been that electric utilities, plus the cotton fields, have moved the textile industry from the crowded New England towns southward to better conditions and nearer the scene of production, and so it is throughout the nation. In the wake of industry's triumphant march to the country have been established new subcenters of business which are also relieving congested conditions in the cities. Agricultural values have been increased, taxes have been lowered, educational facilities vastly bettered and the long needed diffusion of manufacturing and agriculture brought about. The farmer may now raise a more diversified and perishable crop with the assurance of a ready market at his door. All of which has had an enormous beneficial effect on a vast majority of our people. And remember, my friends, it is the happiness or discontent of the mass of our population that will make or break our nation.

Having directed you to a few of the electric utilities' contributions to the three great pillars of society, the home, agriculture and industry, let us contemplate the national significance of some of the achievements of these paragons of public service.

During the World War electric utilities were sorely tried, but proved equal to the emergency. By the mobilization of their resources through interconnection and the establishment of superpower systems, they were able to prevent a disastrous power shortage which was a most important asset to national defense, and now stand as a mighty bulwark for our economical peace-time safety, as was so nobly demonstrated in the recent Mississippi flood.

Their incessant activity in the promotion and practice of Safety First principles has saved thousands of lives besides inducing other industries to do likewise.

Electric utilities have been of far-reaching assistance to the stupendous advancement of medical science. The X-ray has removed the guesswork of surgery, and for electricity's successful and extensive use in the treatment of pain and disease, we joyfully hail it as a God-given blessing to suffering humanity.

They have given the spark of life to the telephone, the telegraph, the radio and the talking picture; which have transmitted the human voice and intelligence to the four corners of our country.

The automobile has been an enormous factor in our commercial and civilization's advancement. Mass production, possible through the use of electric power, has made this vital necessity an economical, universal possibility.

They have pioneered the thrift-begetting idea of customer ownership.

They have arrested the flow of the mountain torrent, forced it to whirl the giant turbine and then released it to irrigate millions of acres of increased population, besides aiding in flood control.

By constant improvement they have reached undreamed of economy in the operation of the steam turbine, with a vital conservation of coal and fuel oil.

By the use of their dependable commodity, railway electrification is fast becoming universal, with elimination of smoke, regeneration of power and cheaper operation.

We must credit them with the dazzling splendor of electrical display, as it nightly sparkles and flashes before the multitudes, standing as an incomparable exponent of outdoor advertising.

Their gleaming beacons are guiding the lonely air pilot from coast to coast.

Electric utilities' infallible service to street lighting has spread that gloom-dispelling radiance which has diffused its cheer along every thoroughfare, from the most isolated Main Street to the Great White Way.

Their nation-wide program of construction has released a golden stream of prosperity that has flowed into every channel of commercial endeavor. Through the medium of electric-driven labor-saving machinery with increased production and efficiency, the American worker has become the master of his environment, enjoying a wage scale and standard of living which surpass those of any other nation.

Finally, we must realize our indebtedness to the fact that the reason for the unparalleled progress of this indispensable utility is due to the liberal policies of our glorious democracy toward an enterprising and progressive people, whereby private capital and individual initiative have always been allowed a fair profit and remuneration, which freedom and encouragement have stimulated them to the greatest endeavor and achievement. For, inasmuch as we have come to realize the virtues and unlimited possibilities of these great public servants, with their vital contributions to our community, state and national life, touching and benefiting every man, woman and child in every walk of human activity, we should, in all sincerity, give voice to a heartfelt thanksgiving and appreciation that we and our posterity are permitted to live in this modern dynamic age.

## *Customer Ownership**

*Regret is expressed in the curtailment of customer ownership activities on the part of member companies and a resumption of this work is urged.*

DURING 1930 member companies showed little activity in customer ownership sales, due principally to the decline in the demand for new capital and also to the fact that advantage was taken of the good bond market to raise capital by the sale of senior securities.

The only member companies reporting activities were: Pacific Gas and Electric Company, Southern Sierras Power Company and Southern California Edison Company Ltd. The California Oregon Power Company continued to make stock sales in their California territory.

While concrete figures are not yet available, it is felt that the loss in stockholders by member companies reported last year has come to a halt and that the number of new stockholders is increasing again at a moderate rate.

### Good Market for Additional Securities

There is no doubt in the minds of the committee that, due to the wonderful market stability shown by power company preferred stock during the last twelve months, the public generally are convinced more than ever of the merits of such securities as "gilt edged" investments, and that the territory served by the member companies could absorb many millions of additional preferred stocks, provided the utilities needed to raise additional capital.

Your committee has co-operated with the N.E.L.A., sending various articles and news items of the customer ownership activities of member companies, and it is expected some of these will appear in the N.E.L.A. Bulletin in the near future.

### Resumption of Activity Urged

The committee feels that it is a matter of great regret that member companies have been forced to curtail customer ownership activities due to conditions mentioned heretofore and believes they should be resumed at the earliest opportunity, as there is no question as to the immense benefits obtained by such campaigns in helping to keep the public and consumers informed of the power companies' activities in building up the community and simultaneously raising new capital at a very moderate cost.

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* Report of committee on customer ownership, Public Relations Section. F. L. Greenhouse, Southern California Edison Company Ltd., chairman.
Los Angeles Gas and Electric Corporation: F. E. Seaver.
Pacific Gas and Electric Company: E. J. Beckett.
San Diego Consolidated Gas & Electric Company: M. B. Fowler.
Southern California Edison Company Ltd.: O. V. Showers.
The Southern Sierras Power Company: A. S. Cooper.

## *Industrial Relations**

*This committee being closely associated with the Pacific Coast Electrical Bureau, the record of its activities is really the record of the accomplishments of the bureau. The re-organization of this body during the year has placed it on a better basis for more efficiently serving the industry and has already resulted in better interindustry relations.*

THE personnel of this committee and its activities are correlated with the Pacific Coast Electrical Bureau.

During the association year numerous conferences have been held with contractors and dealers and plans evolved which have been placed in effect with individual companies. This work has already shown a very definite tendency materially to improve relations within the industry.

Further accomplishment might be noted in the reorganization and revitalization of the Pacific Coast Electrical Bureau; the reinstallation of a bureau field staff and the establishment of regional offices in the southern, central and northern portions of the state of California.

As an outgrowth from the Red Seal plan inaugurated by the bureau several years ago, the new plan of operation also incorporates other statewide co-operative activities. At the time of writing this report, the new organization is just getting under way. It is anticipated, however, that during the ensuing year the accomplishments of the industrial relations committee, functioning as the Pacific Coast Electrical Bureau, will permit of a much more comprehensive report.

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## *Women's Committee Report*[2]

*In addition to the excellent work done by the individual company committees, two subcommittees, covering home service and safety and first aid, have this year accomplished notable results.*

THE work of the women's committee of the Pacific Coast Electrical Association may be summed up in the accomplishments of the individual women's committees of the member companies which function under its direction. These local committees, under the competent management of their respective chairmen, have been extremely active this year in promoting the spirit of service among the women employees and in smoothing the relationships between the women of the community and the public utility.

A special effort has been made to encourage women employees to become members of the Pacific Coast Electrical Association and it is gratifying to report that 96 women have taken advantage of this opportunity.

Great interest has been shown in the employee's public speaking contest, and many of the member companies have responded with a goodly showing of women contestants. The quality of the women's contributions certainly has not ranked below that of the men, either in subject matter or in poise and general delivery.

In general it may be said that the women's committees in every company have endeavored to tie-in closely with the activities of their respective commercial departments. Wherever possible the appliance being featured by the merchandising department for the month was made the subject of current discussion in the women's committee. In all cases, the advantages of electrical homemaking have been stressed, with the idea that the united conviction on the part of the women employees of the public utility that electricity is a

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* Report of the committee on industrial relations, Public Relations Section. W. L. Frost, Southern California Edison Company Ltd., chairman.
General Electric Company: R. M. Alvord.
General Electric Supply Corporation: D. E. Harris.
Graybar Electric Company: H. L. Harper.
Los Angeles Gas and Electric Corporation: A. B. Day.
Newbery Electric Corporation: G. E. Arbogast.
Pacific Gas and Electric Company: R. E. Fisher.
Valley Electrical Supply Company: H. H. Courtright.
Westinghouse Electric & Manufacturing Company: A. E. Hitchner.

[2] Mrs. Nyra G. Letchworth, San Joaquin Light & Power Corporation, chairman.
Arizona Edison Company: Miss Wilma D. Jones.
Coast Counties Gas & Electric Company: Miss Alma Freeburg.
Electrical West: Mrs. Dorothy Peede.
Graybar Electric Company: Mrs. Mercedes M. Gaffney.
Hawaiian Electric Company Ltd.: Miss Miriam Jackson.
Los Angeles Gas & Electric Corporation: Miss Marvel Murray.
San Diego Consolidated Gas & Electric Company: Mrs. Marge M. Edwards, Miss Nell Molloy.
San Joaquin Light & Power Corporation: Miss Clyda Weems.
Southern California Edison Company Ltd.: Mrs. Jeanette I. Rees.
Valley Electrical Supply Company: Mrs. Mabel E. Tripp.

boon to the housewife, could not fail to have its effect on those with whom they come in contact. In many cases the members of the local women's committees have been able to adjust cases of dissatisfaction on the part of consumers, reporting the complaint to the proper department or employee for adjustment.

### Home Service Subcommittee

An interesting phase of the work of the home service subcommittee this year has been the collection of information in regard to unusual applications of domestic appliances. The women of the Los Angeles Gas and Electric Corporation, for instance, report that many movie stars find it more economical to install large electric refrigerators in their homes for the storage of furs in summer than to patronize commercial cold storage plants. Each chairman is to be on the alert to note such new developments and to report these for the benefit and interest of the other companies.

The women's committee of the Los Angeles Gas and Electric Corporation has also organized a civic club for wives, mothers and sisters of employees which will promote company loyalty and will greatly widen the avenues of contact with the housewives of the community.

*Fig. 1. Members of the executive council of the new women's club of the Los Angeles Gas and Electric Corporation: Front row, left to right, Mrs. Oscar L. Moore, Mrs. William M. Henderson (vice-president), Mrs. William Maddock; back row, left to right, Mrs. Addison B. Day, Mrs. Daniel L. Scott, Miss Clarita Scott (secretary), Mrs. Frank R. Knight, Mrs. Ernest N. Simmons, Mrs. Eugene P. Ramsay (president), Mrs. Harry L. Masser, Mrs. George S. Campbell (treasurer), Mrs. Harold B. Wells, Mrs. Eugene A. Lodmell and Mrs. Ralph U. Fitting.*

The committee of the Southern California Edison Company Ltd. has been sponsoring a class on the subject of "Socialistic Tendencies Against Individualism From Early Times to the Present," conducted by Dr. Hoxey, economist and research engineer of their company, which is attended by 26 young women. Another group in the Santa Monica section has organized a class in homemaking, held in the company's demonstration kitchen. The programs of this class have followed closely the seasonal schedule of the merchandising department, featuring a certain appliance at the same time that it is being featured in sales.

The San Joaquin Light & Power Corporation committee has organized and carried out some most effective public service work during the past eight months. Under the direction of the women's committee a group was formed to care for families of the unemployed not otherwise cared for by organized charities. Food, clothes, fuel and other necessities are furnished these families on a systematic basis, thus relieving much distress in the community.

### Safety and First Aid in the Community

This year the subcommittee on safey and first aid has concentrated on the prevention of accidents and on the spreading of information in regard to first aid for home, school and street, rather than on a state meet for first aid teams. Following the schedule suggested by the National Congress of Parent-Teacher organizations, the following programs have been sponsored:

1. The House We Live In—by a home maker.
2. Outguessing the Child—by a parent.
3. Electricity and Gas, Their Use and Abuse—by a home service member of the women's committee.
4. Flaming America—by a representative of the fire department or of a fire insurance company.
5. When Accidents Occur—by a physician or by the chairman of the first aid work, women's committee.
6. Accidents—A Community Problem—by a police or traffic officer.

# Purchasing and Stores Section[1]

## PURCHASING DIVISION REPORTS[2]

### *Traffic**

*The duties of the traffic manager are here analyzed and it is recommended that studies on the subject of traffic be continued throughout the coming year.*

A TRAFFIC department may be broadly defined as a department charged with the responsibility of obtaining efficient and economical transportation service between the areas of production and distribution. Primarily, such departments are concerned with protecting the interests of their employers, but in a broader sense their duties include the work of obtaining adequate service at fair rates for all users of transportation facilities. This is accomplished through co-operative action with traffic departments of other concerns.

Transportation costs are important items in the prices of raw materials as well as finished products and good service is necessary to users of transportation if goods are to be produced and distributed efficiently.

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[1] Executive Committee: W. de Waard, San Diego Consolidated Gas & Electric Company, chairman. G. M. Richardson, Southern California Edison Company Ltd., vice-chairman.
Los Angeles Gas and Electric Corporation: William Maddock.
Pacific Gas and Electric Company. J. H. Hunt.
San Diego Consolidated Gas & Electric Company: C. D. Weiss.
San Joaquin Light & Power Corporation: S. E. Hickman, D. P. Mason.
Southern California Edison Company Ltd.: W. J. McCullough, H. O. McKee, E. F. Watkins.
The Southern Sierras Power Company: C. A. Kelley.

[2] C. A. Kelley, The Southern Sierras Power Company, chairman.
Central Arizona Light & Power Company: C. A. Hulse.
Coast Counties Gas & Electric Company: E. Crick.
Los Angeles Bureau of Power & Light: D. P. Nicklin.
Los Angeles Gas & Electric Corporation: T. Parks, L. A. Reed.
Pacific Gas and Electric Company: J. Hunt, E. O. Mahoney, F. Sherwood, E. Wood.
San Diego Consolidated Gas & Electric Company: C. J. Gamble, S. R. Robinson.
San Joaquin Light & Power Corporation: S. E. Hickman.
Southern California Edison Company Ltd.: J. L. Gray, F. F. Henry, C. H. McWhorter, W. I. Priest, E. F. Watkins.

* Report of committee on traffic bureaus, purchasing division, Purchasing and Stores Section. E. O. Mahoney, chairman. G. F. Gamble, C. H. McWhorter, L. A. Reed, F. R. Sherwood.

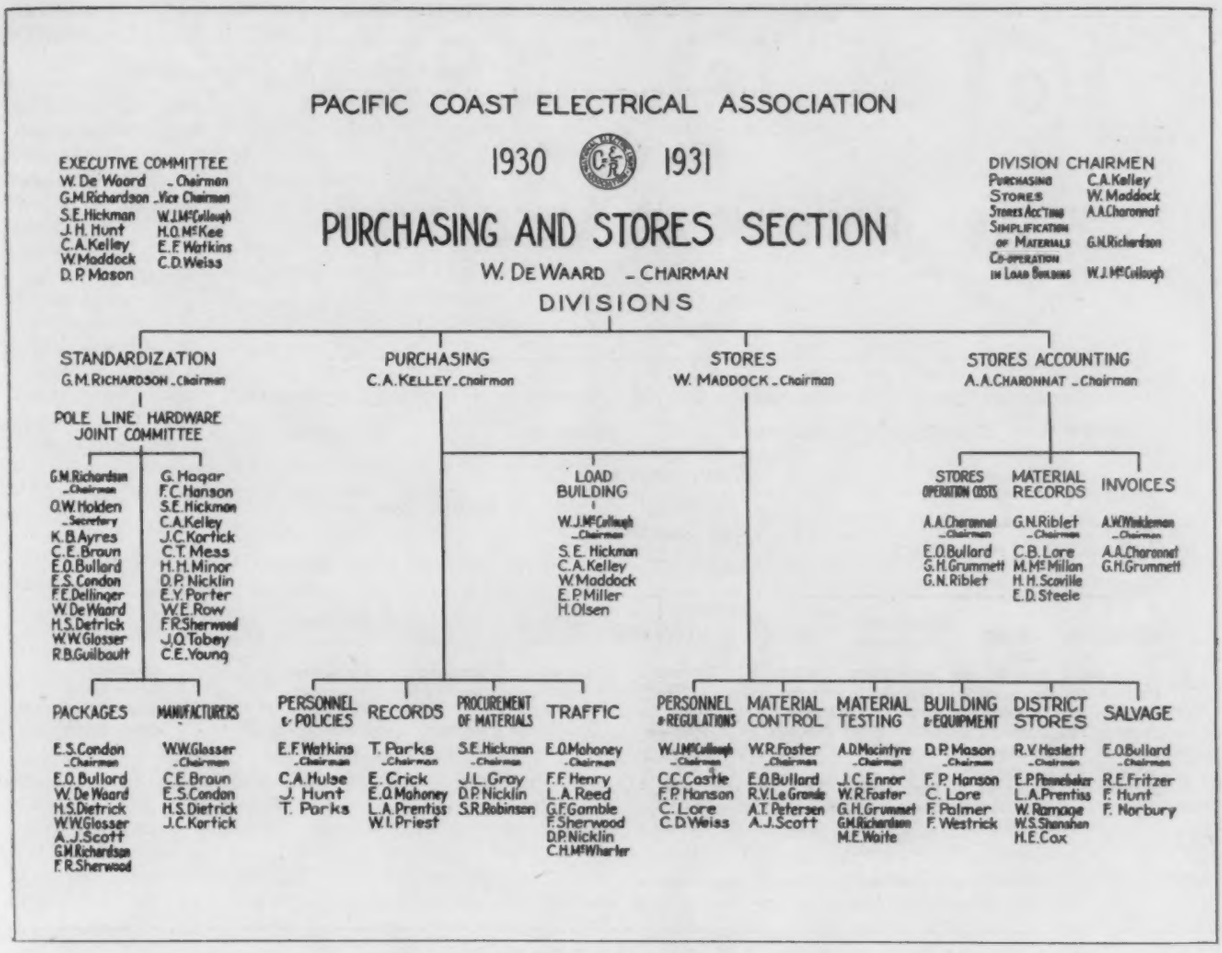


*Fig. 1. Personnel, Purchasing and Stores Section.*

### Value of Traffic Bureau

The position of traffic managers grew out of the need of industry for men technically equipped to protect its interests in transportation problems. Users of transportation facilities need men with a knowledge of rates, classification, shipping procedure, routes and the legal rights of shippers and carriers.

The cost of distributing products is of growing importance to producers and consumers in these days of strenuous competition. Traffic management, in so far as it is related to industry, concerns itself with this problem of distribution.

### Forms of Transportation

For years the railroads have been the most important means of transportation. Most of the technique of industrial traffic management has been developed in connection with railroad transportation. Steamship lines are closely affiliated with the railroads and the work of the traffic manager is much the same in connection with these carriers as with the railroads. Motor truck transportation, as at present developed, must be considered in the light of a competitor.

The present day traffic manager must be familiar with all the present forms of transportation in order to obtain the most desirable service at favorable rates.

### Duties of Traffic Manager

The duties of traffic managers vary, depending upon the lines of business. A distinction may be drawn between industrial and commercial traffic managers. Industrial traffic managers are those associated with industrial plants. Commercial traffic managers include those associated with commercial organizations, such as chambers of commerce, boards of trade and traffic bureaus. In many respects the duties of the two classes of traffic managers are similar, but there is enough difference to warrant a distinction being drawn.

The traffic manager of a concern is the purchasing agent of transportation.

There is no one type of organization of a traffic department that can be recommended above all others. The factors influencing the organization are the character of the commodity dealt in and the volume and nature of the tonnage. Influenced by these factors, the staff may range from a shipping clerk to a highly organized department. The importance of traffic work is recognized by heads of large enterprises and smaller concerns are following their lead. Many new departments are organized each year.

Foremost among the duties of the traffic manager is that in connection with rates. Those concerned with traffic work must give close attention to rail, water and highway charges. Rates must be obtained from carriers and submitted to other departments of the industry. Well organized traffic departments must collect and maintain a file of traffic necessary to serve the industry. Tariff studies are made by many traffic departments in order that prospective changes in rates or service may be anticipated. Other duties are: Freight bill auditing, preparation of claims, routing, tracing shipments, arranging for car supply and expediting shipments.

The heads of industrial concerns are learning to appreciate the value of trained traffic and transportation men. It must

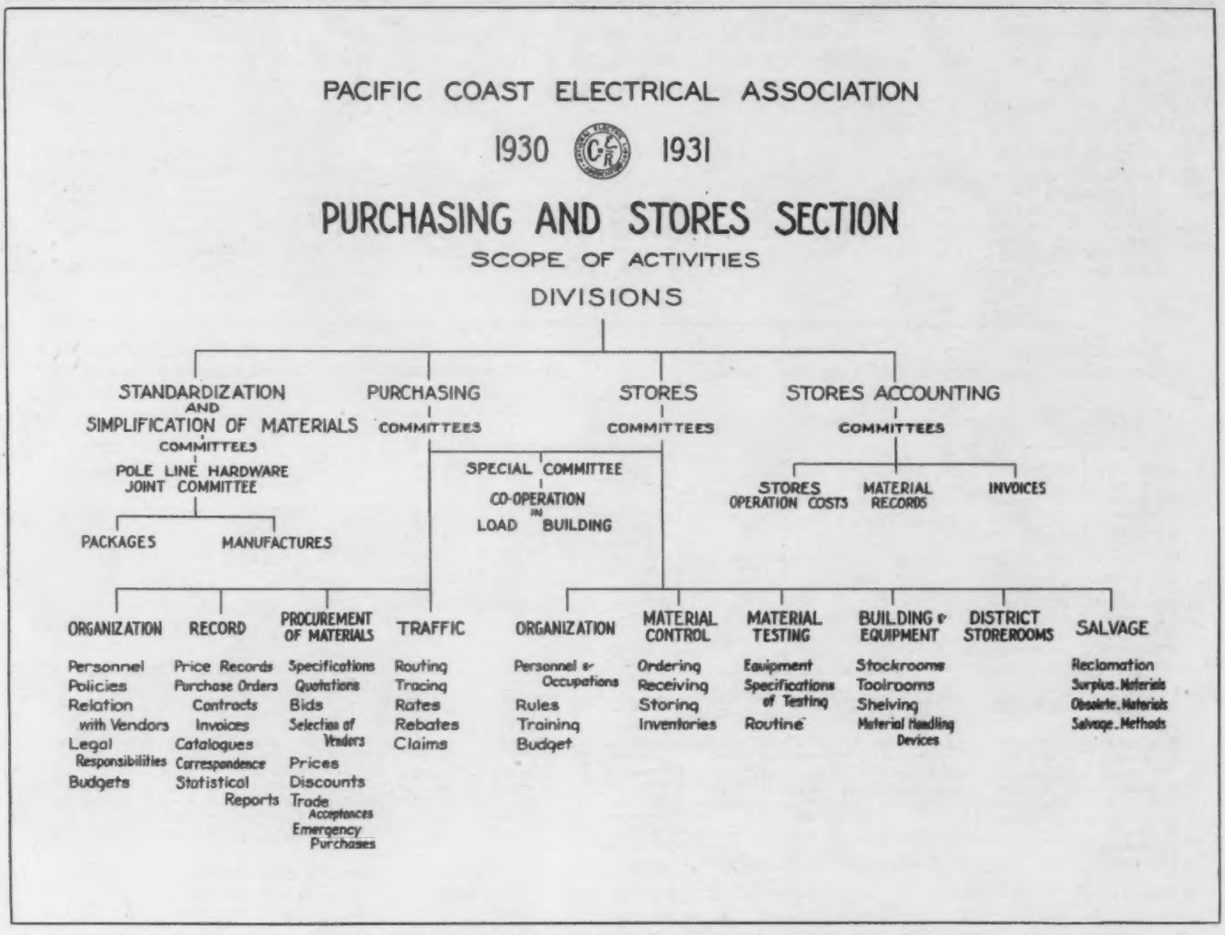


*Fig. 2. Scope of activities, Purchasing and Stores Section.*

yet be demonstrated to managers of smaller concerns that they cannot afford to be without expert traffic advice.

In connection with the purchase of major apparatus, it is the recommendation of your traffic committee that this class of equipment be purchased f.o.b. destination. It is felt that there are certain advantages which make it advisable to purchase on this basis.

### Recommendations

The subject of traffic is one of considerable interest and the traffic committee recommends that it have a prominent place on next year's program.

It is suggested that the traffic managers and the purchasing agents of the various member companies refer for further information on this subject to the bulletin issued in 1930 by the U. S. Department of Commerce, entitled "Industrial Traffic Management," by Wayne E. Butterbaugh, Domestic Commerce Series No. 39. This can be procured from the Superintendent of Documents, Washington, D. C., for 30 cents per copy.

# STORES DIVISION REPORTS[1]

## *Personnel Training**

*A definite plan of training the employee, at the time he is first introduced to his duties and continuing throughout the term of his employment, will result in greater loyalty and better service to the organization and in greater opportunity and contentment for the employee.*

PERSONNEL training should, we believe, start in the personnel department, if such a department is in existence; if not, then in the employment department or with the man delegated to hiring employees. In the stores department, the ideal method would be to employ young men with the equivalent of a high school education and to start them in the physical end, thus allowing them to become acquainted with materials, which knowledge would be of great help,

* Written by C. C. Castle for the committee on personnel and regulations, stores division, Purchasing and Stores Section. W. J. McCullough, chairman. C. C. Castle, F. P. Hanson, C. B. Lore, C. D. Weiss.

[1] Wm. Maddock, Los Angeles Gas and Electric Corporation, chairman.
Los Angeles Bureau of Power & Light: W. R. Foster, F. Norbury.
Los Angeles Gas and Electric Corporation: E. O. Bullard, N. McMillan.
Pacific Gas and Electric Company: A. A. Charonnat, F. P. Hanson, H. H. Scoville, W. S. Shanahan.
San Diego Consolidated Gas & Electric Company: R. E. Fritzer, A. T. Peterson, W. Ramage, G. N. Riblet, M. E. Waite, C. D. Weiss, F. Westrick.
San Joaquin Light & Power Corporation: G. H. Grummett, D. P. Mason.
Southern California Edison Company Ltd.: C. C. Castle, J. C. Ennor, R. V. Haslett, F. Hunt, R. V. LeGrande, W. J. McCullough, H. O. McKee, F. Palmer, G. M. Richardson, E. D. Steele.
The Southern Sierras Power Company: C. B. Lore, E. P. Pennebaker, A. J. Scott.
Tucson Gas Electric Light & Power Company: L. A. Prentiss.

regardless of what department they might be located in permanently.

### Introduction to Organization

After the prospective employee has made out his examination application, has been successfully passed by the medical department and has reported back to the man employing, his training starts immediately. If he is turned over to a foreman who simply puts him on the job without an introductory talk, without showing him the location of the locker rooms and washrooms, or introducing him to the rest of the men in that particular department or gang, without telling him some of the policies of the company, then his training has not been started in the right manner. The psychological effect on the new employee of such an introduction is far-reaching. Do you remember how you felt when, perhaps, you started to work at some new place? Would you not have entered into your new work with considerably more zeal if you had been taken around, told some of the policies of the firm, introduced to the various fellows with whom you would be working?

### Follow Up

The next step in the training of the employee is for the foreman, or the man who hired him, to drop around occasionally and talk to the man. Once the employee is started off with the right mental attitude, usually you should have no difficulty. After one to three months, the employee should be either given a small raise in salary or, if he is not satisfactory, he should be transferred to another line of work, after which, if he fails to make good, he should be let go. The small raise shows the man better than any other way that he has made good. Of course, when he is informed of the raise, he should be talked with regarding his past and future activities—how he likes the work he is doing, what he aspires to become, etc. etc. We find the personal talks with the men pay us large returns. Such a personal interest taken in the man, his ambitions and his family, makes the average employee more satisfied with his work, better contented with his surroundings, happier and naturally healthier, all of which helps to make him a loyal employee and, best of all, a good citizen.

### Training and Discipline

Encourage the employee to learn his own job thoroughly before he starts to learn another. If he is on his toes, he will in all probability not need much urging to get all there is from the work he is doing and will look around for other things to do. Impress on his mind that training is simply the open door to opportunity.

Train the employee both mentally and physically—will power also needs training. It takes training and discipline in the lower positions to fit one to fill the higher positions properly. One who keeps himself in training will obtain new points of view that will keep his work fresh and interesting and, as a rule, he can find plenty of opportunity to apply what he learns. Almost every job has practical problems of its own, or problems closely related to the work, where newly learned principles and methods may be applied.

Training recognizes that "that which one has, can be developed, and that which one has developed, can be developed to a higher degree." This is proved by the fact that you can take a worker with the capacity of a given number of work-units per day and, through training, can develop his capacity to several times that amount; also, those who now can handle small groups of helpers can develop their executive ability for handling much larger groups, with a wider range of responsibilities.

Advancement of any kind depends on the right application of the right ideas. Right ideas come from knowledge; right application comes from skill and both of these are the product of training. Training is drawing out, developing and disciplining one's power so as to increase one's ability to perform. However, this training is all lost, insofar as the organization is concerned, unless the employee's mental attitude, his respect for the company's policies and his spirit of loyalty and co-operation are developed along with his other training.

### Co-operation With Fellow Workers

Regardless of how good an employee may be, if he cannot get along with his fellow workers, cannot adopt the company's policies as his own, cannot put his shoulder to the wheel when an emergency arises, he had better be dropped.

Training fixes habits and habits can either be "result producing" or "result reducing." Firms that systematically train their employees are able to determine, almost by exact measurement, the difference in the results produced by those who are profiting by the training and those who are not. One who is trained physically and mentally and in the exercise of strong will power can do things which others consider impossible. He will plan, initiate, perform and execute; he can tackle a most difficult problem and find the right solution, his solution will not stop with figures but only with accomplished fact. Such an individual is an organizer, an executive, a leader and director of others; he is the logical candidate for the big job.

### Educational Courses

In the larger utility companies, opportunities are offered all employees to improve their education and fit themselves for better positions by educational courses. The employee is urged to improve his knowledge through taking courses, either in the night high school, the universities, with the N.E.L.A. or with lectures or studies offered under the direction of the educational committee of the company. Some companies pay 50 per cent of the cost of the course after a satisfactory completion and give diplomas to the employees finishing the course with a passable grade.

Through the installation of a plant library, by circular letters of instruction, by sending storekeepers, stockmen, shipping department men, and others to construction jobs and district stores to see the conditions under which the man in the field is operating, likewise by bringing these men into the general stores to see how the various departments function, the company brings about a mutual understanding between employees, resulting in co-operation and a willingness to help each other that could not be obtained in any other manner.

### Accident Prevention

In addition to this, through the installation of Careful Clubs and safety committees, before whom accidents and means of prevention are discussed, as well as ideas of safety brought forward by members (who rotate through the year), the employees are brought to a realization of the importance of doing their work in a safe manner, not only for themselves but for others working with them.

### Instill Idea of Service

The most important thing is to get the employees to realize that they are all working for one common cause. The aim in training should be with the idea, not only of service to the department, but also service to other employees, to other departments, to the public and to the company as a whole.

The employee has a great many advantages, such as permanent employment (a person who has been able to stay with a company for a long period of time is really rewarded by having permanent employment), the privilege of being a partner in the organization through the stock purchasing contract arrangement, the privilege of vacation and the pension plan. To the new employee, the pension is in the indistinct future, but to those who have been in the company's service

ten, fifteen or twenty years, the pension plan is a real institution and one looked forward to as affecting them personally. The very liberal policies of the company in regard to the care of employees, when they are laid up for sickness or other reasons beyond their control and for which the company is not responsible, in leaves of absence and the benefit fund, in the good surroundings and exceptionally good working conditions—all of these, together with the fact that the company promotes men from within the ranks of the organization, and the expansion of the company, which is an opportunity in itself, are tangible rewards to service.

These are the incentives which make the personnel happy and which encourage them to give the best they have. With proper training, the right mental attitude and loyalty, they are certain to receive the reward for which they are looking, if they have the initiative to start, the persistence to carry on, and the dependability to inspire and deserve trust.

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## *Storeroom Personnel and Occupations**

*Suggestions for the selection and development of the storeroom personnel are here given.*

THE management of a large public utility warehouse or stores department is comparable to that of a chain grocery or hardware business—in fact, to any business where the problems are of storage, transportation, and of accounting, with service to the consumer as the paramount factor by which is measured success or failure. The consumers, in this case, are the various other departments of the utility and their dependency upon the warehouse should be analogous to your contact with the grocer.

This statement may prompt the query as to why the stores department, which is just another department within the company, should be invested with the control of all material necessary for the utility's operation and development. The answer is covered by a statement of the four primary functions of storekeeping.

### Functions of Stores Department

Unquestionably, the chief function of the stores department is to be prepared to supply the demands of the other departments, either from stock on hand, by manufacture, or by purchase, depending upon the urgency of the need and continued usage of the article. Naturally this calls for a close knowledge of the company's activities, coupled with a familiarty with trade and transportation conditions, in order to anticipate these demands.

The next function, in order of importance, is the control of inventories. These should be kept at a minimum, commensurate with demands and the type of commodity. This is particularly true of the gas and electric industry, on account of the very nature of its business, as the continued increasing use and application of our product has stimulated the manufacture, design and perfection of machinery and appliances for the creation and the consumption of those products; consequently, care must be exercised to prevent an excess stock and its subsequent obsolescence. Overstocking is reflected in excess interest carrying charges; indirectly it affects the company's income, especially under conditions such as in the present business depression.

The third primary function is that of salvage. The stores department should undertake the repairing and reconditioning of all materials and apparatus, which will economically warrant the procedure for re-use. Otherwise, such items should be segregated, according to their value as second-hand apparatus or component metals, and disposed of as such.

The fourth and very important function is that of accounting. Broadly speaking, this provides for the clerical contact of the stores department with the outside, both within and without the company, providing the records of all transactions affecting the department and the compilation of such data into periodic statements or reports for the general guidance of the business and their inclusion in the general statements of the utility.

### Personnel

The aforesaid primary functions, with which are associated many other activities, comprise the storekeeping problem; the type and caliber of the employees charged with their execution decides the ultimate outcome. It is evident that men and women of all grades of training and experience are required: experienced material men, supervisors, foremen, accountants and clerks, shipping and receiving clerks, truck drivers, crane operators, helpers, laborers, etc., all are required to operate a utility stores department.

There was a time when the employee who did not seem to fit anywhere else and he who had outlived his usefulness in other departments, as well as the unfortunate who may have been injured in company service, made up the source from which the supply department was expected to create its personnel. The pension and retirement system has greatly relieved this, and a higher standard, with a more efficient employee, has resulted.

The man of today must be careful, for material handling has its hazards; he must be accurate, for inventories must be correct; above all, he must be co-operative, for that means "Service."

### Organization

The acquiring of such a personnel may be accomplished by three methods: First, by employing trained men; second, by the transfer from other departments of those who have shown an aptitude for this work, and third, by the development of the individual in the department. The last two methods are the most advisable, as it encourages young men to seek employment in this department, knowing that promotion follows their qualification.

It is not to be inferred that all men employed should be considered prospects for managers or superintendents, as this department will continue to have a place for the laborer and the individual of limited ability, the same as in any other business. Nevertheless, a certain percentage should be ready for advancement and should qualify for vacancies or new positions, without disturbing the stability of the organization.

### Selection of Employees

In the selection of new employees, with the possible exception of emergency casuals, prospects should be picked and not "just hired," requiring at least a high school education or its equivalent, together with a much needed penmanship qualification, which is very important in this department. Other traits and abilities must be passed on, depending upon what department of the store's personnel he is to qualify for, keeping in mind at all times the importance of determining the prospect's capability of co-operation with others.

Special endeavor should be made to see that the new employee is properly initiated in his new duties and that he becomes acquainted with his associates, in order to make it easy for him to establish himself in his new surroundings. He should be instructed in the company's policy of "Safety First" and advised of its policy toward the employee and its activities in general. Make him feel at home so that he

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* Written by F. P. Hanson for the committee on personnel and regulations, stores division, Purchasing and Stores Section. W. J. McCullough, chairman. C. C. Castle, F. P. Hanson, C. B. Lore, C. D. Weiss.

may become interested in his new job; in other words, that he may become an asset and not a liability.

If properly watched and directed, the first six months should indicate the possibilities of the new employee and, if the verdict is adverse, it should then be decided whether he be transferred to another job or dismissed. Possibly the latter action would do him a favor, as no doubt he is in the wrong place and is thereby prevented from becoming "dead timber" and merely a "jobholder."

Actual experience on the job, without other avenues of instruction and influence, is not sufficient fully to develop the employee. Periodic departmental meetings for the discussion of shop problems, an occasional talk by men from other company departments, an educational movie, a suggestion box and educational courses, all make for his benefit. Moderate competitive sports, a smoker, a social, and like activities, lead to a better understanding and co-operation among the employees.

### Contact With Other Departments

Leading hands in the organization should be encouraged to contact men of other departments of the company, as well as those of other utilities and also to take an interest in the proceedings of organizations which are devoted to the industry, for the purpose of learning "what *not to do*" as well as "what to do."

In conclusion, I would say that while utility warehousing or storekeeping has its peculiarities, its foundation is based on the ethics of good business. The properly developed and trained employee is the main factor in low operating costs, for it is he that holds down your inventory, expedites orders, and makes it easy for other departments to "buy your wares," resulting in your department becoming one of service in reality.

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## *Ordering Material**

*The ordering of material is one of the most important functions of the stores department, for it is only by exercising the utmost care in ordering that we can hope to have sufficient material on hand at the time it is required, and, on the other hand, to keep the investment in material down to the lowest possible point.*

TO MAINTAIN a well balanced stock, the storekeeper must give serious consideration to the following factors when ordering:

A Quantity on hand at time order is placed.
B Average monthly requirements.
C Business trend.
D Source of supply.
E Market conditions.
F Thorough knowledge of construction program.
G Provision of spare parts for emergency purposes.
H Stock of appliances to meet seasonal demand.

### Salient Points Involved

The above factors are determined as follows:

*Quantity on Hand*—The quantity on hand is either supplied by the stock card clerk or the section stockkeeper, and in the majority of cases is the minimum stock quantity.

*Average Monthly Requirements*—The average monthly requirements are arrived at by the past record of the material used, as indicated on the stock cards.

*Business Trend*—Whether business is increasing or decreasing is determined by a study of material control. The storekeeper must keep in contact with the other departments and in particular with the engineering department.

*Source of Supply*—The source of supply is furnished by the purchasing department and the past record of purchases is a good index as to the approximate time it will require to procure material.

*Market Conditions*—Under this heading should be considered price-splits, price at time purchase is made and trend of market.

*Construction Program*—The storekeeper should be furnished with a copy of the approved budget and should be advised as to the schedule of the work so authorized. The material list, on authorization of work orders, must be checked. Close co-operation between construction, operating and stores divisions is necessary properly to control stocks.

*Emergency Spare Parts*—Such information is ordinarily furnished by the operating department.

*Appliances*—This information is generally furnished by the merchandising department. The merchandising department should keep in touch with this class of material and advise the storekeeper of campaigns scheduled. The appliances for the gift season must be ordered well in advance.

The minimum quantities of standard material to be carried in stock must be determined by studying the periodical use of materials, in approximately 90-day periods. From this study can be set up an ordering point, which must be indicated on the stock card; then the stock card clerks will notify the order clerk when the material should be re-ordered.

### Information Required

In ordering material the following information must be furnished to the purchasing department:

1. A correct and complete description of material required, which will be found in specification book, standard handbook or standard records, unless it happens to be a special item.
2. The quantity required.
3. The delivery point.
4. The date of delivery. Whenever possible, deliveries should be scheduled, particularly in cases of large construction jobs. By proper scheduling of orders, the material and equipment will be delivered direct to the job as required.

### Standard Packages

All material should be ordered in standard packages whenever possible and should be grouped by classes to facilitate posting and to minimize the number of purchase orders to be issued, as the purchasing department will generally prefer to place orders for the same class of material with one vendor.

The order clerk or his assistant should maintain a follow-up system on all orders, in order to have the material on hand when required, and any cases of delayed deliveries should be reported to the purchasing department for their information in placing future orders.

The proper storing of material is a very important factor in the ordering, and in all cases where the material is stored in more than one location, the bin tags should be marked, showing the location of the balance.

The ordering of emergency and spare parts is growing in importance, due to the growth of the companies and the class of service now rendered. All special power plant equipment should be stored at the various power plants, so that it may be used at a moment's notice, and the operating department heads should accept a good share of the responsibility as to the quantity to be carried in stock, as they are in the best position to know.

The storekeeper, or his assistant, and the order clerk, should approve all orders for material, with the exception of special items, as their knowledge of the material on hand and information as to the material to be ordered, is the basis of the control of "material dollars."

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* Written by W. R. Foster and Wm. Maddock as the report of the committee on material control, stores division, Purchasing and Stores Section, W. R. Foster, chairman. E. O. Bullard, R. V. LeGrande, A. T. Peterson, A. J. Scott.

# *Material Testing**

*The following report gives equipment for testing, specifications for testing and routine used by three of the member companies for all materials and apparatus used.*

EQUIPMENT used for testing, specifications of testing and routine practices of three member companies are here reported.

### Equipment Used for Testing by Pacific Gas and Electric Company

*Tensile, Compressive and Bend Tests—*

*Universal Testing Machine*—This machine is used for comparative tests on the products of various manufacturers and to check materials purchased for compliance with specifications. Tensile, compressive and bend tests are made on metal specimens from structural materials of all kinds, also tensile tests on copper, aluminum and steel wires and cables, on rope, bolts, and line hardware of all kinds, including insulators, guy wire clamps, suspension clamps and other suspension units.

In connection with this machine various special apparatus has been developed. A 4-ft. latticed column extension is used in testing ropes, cables, wires, etc., thus making it possible to pull an 8-ft. length.

* Report of the committee on material testing, stores division, Purchasing and Stores Section. A. D. MacIntyre, chairman. J. C. Ennor, W. F. Foster, G. H. Grummett, G. M. Richardson, H. E. Waite.

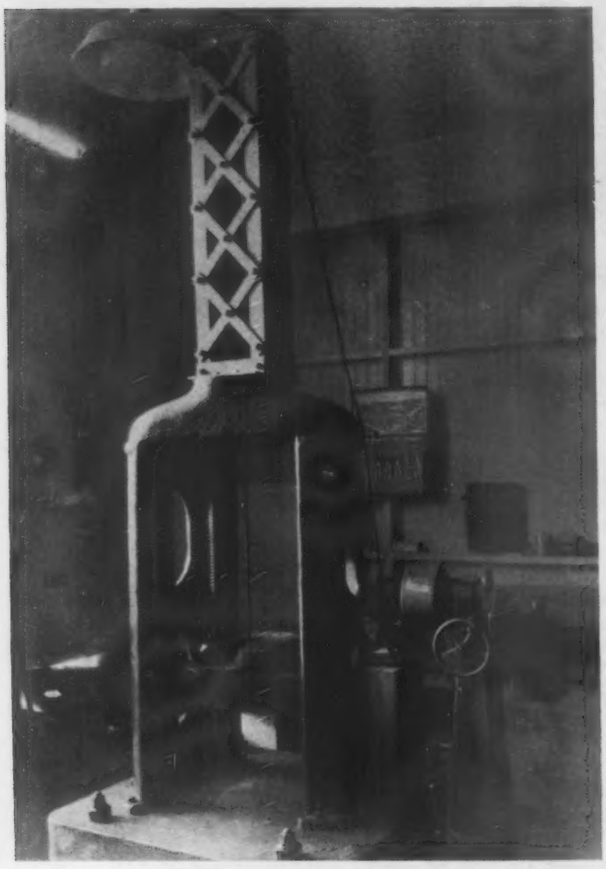

*Fig. 1. 4-ft. extension on testing machine, with cable in place for test. Note that this extension, which is bolted to the head of the machine, is very useful in testing rope, cables, etc., requiring greater testing length than that ordinarily available.*

The testing of bolts requires holders which will allow the bearing pressure to apply against the under side of the head and nut. Because of their shape these are called "stirrups," and are made in sizes capable of holding bolts from ¼ in. up to 2 in. in diameter and as short as 1 in. in length, such as guy clamp bolts. A "stirrup" may be clamped in the jaws of the machine or simply slipped through the testing head and held by a steel pin, which is inserted in a hole drilled near the end of the "stirrup."

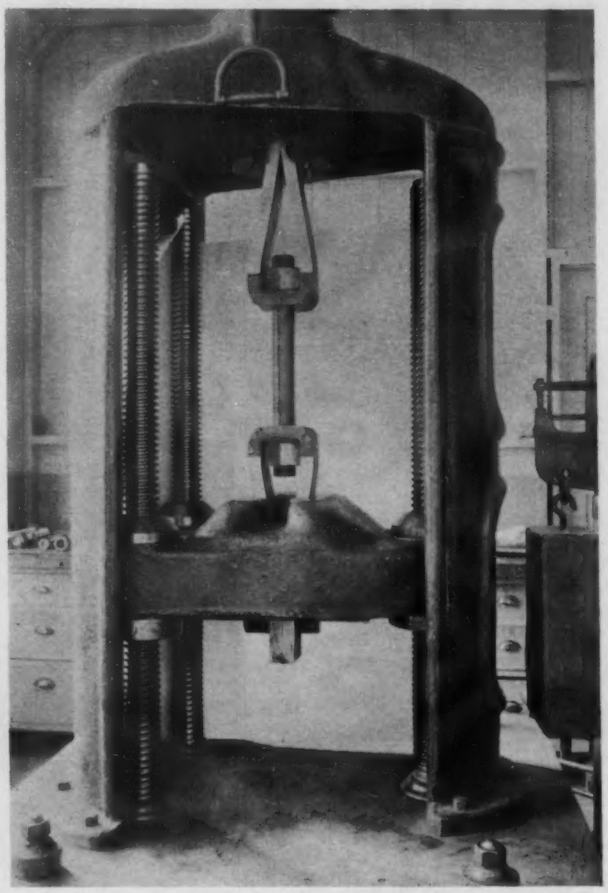

*Fig. 2. Stirrups being used for tensile test of large bolt. Note that the upper stirrup is held in jaws and the lower one by pin.*

*Electric, Chain Block and Attachments*—Many tensile tests require more space than is available in a testing machine or for other reasons the machine is not suitable. Such tests can often be made with a chain block or crane, if adequate means for anchoring are provided. The following arrangement has been found particularly satisfactory:

Two structural steel beams are supported horizontally between two 10-in. steel columns, one 10-in. H-beam being about a foot above the floor and the other, a 24-in. I-beam, 15 ft. above the floor. A 5-ton chain block is hung on a small underslung truck which travels on the lower flanges of the upper I-beam. It is possible to clamp apparatus to the lower H-beam, attach the chain block, and pull up to 10,000 lb.

Thus a crossarm may be clamped to the H-beam, and insulator pins, brackets, service knobs, etc., pulled to failure. The load is measured by a traction dynamometer below the hook on the chain block.

Two wooden poles are inserted vertically between the horizontal H-beams. These are movable and easily removed, being held in position by four flat lugs at top and bottom, bearing against the beam flanges. These may be used for

fastening material to, or as braces between the beams when under heavy load near the center of the span.

The upper I-beam in this arrangement also serves as a crane rail bed for a 15-ton electric crane. As the crane hook may be moved into any position along the lower H-beam

*Fig. 3. Tensile testing rig consisting of columns, beams, chain block and crane. A crossarm is shown attached to the lower beam, with an insulator and pin in place. The offset pull is being applied by the crane and the load registered on the traction dynamometer. For direct pulls, the chain block is used.*

and at various distances from it, cantilever and offset pulls are easily handled.

The crane may also be used for direct pulls against an ancho age installed fo- this pu pose. This consists of a 4-in. slot in the floor, formed between the parallel backs of two 12-in. heavy channels imbedded in the concrete. The ends of the channels are anchored to the footings of two columns which support the crane-ways. Large eye-bolts may be set in the slot and locked in place by a special nut which bridges the slot below the channels. Material to be tested is fastened between the eye-bolt and the hook at the chain block.

*Dielectric Tests—*

Three sets of equipment are available for dielectric tests:

1. A 100-kw., 115,000-230,000/2,300-volt transformer with 100-kw. booster. This apparatus is used for high potential tests on power and distribution transformers, large insulators, bushings and insulating materials.

2. A 10-kw., 125,000/440-880-volt potential testing transformer with induction regulator. This apparatus used for tests on glass and porcelain insulators, bushings, and other apparatus where voltage in excess of 125,000 is not required.

3. Three instrument type potential transformers with high-voltage ratings of 11,000 volts, 22,000 volts and 33,000 volts respectively, are arranged in multiple on the low (110-volt) side, with an induction regulator in the circuit for varying the applied voltage. The high-voltage terminals are free to be connected as desired. These are installed in a wire cage and operated by a switchboard. This apparatus is used for all tests on rubber protective devices, transfo-me- oils, tape, insulating materials, high potential tests of instruments, etc., where voltage in excess of 60,000 is not required.

*Weather Exposure Tests—*

Three weather exposure racks have been erected at locations of diverse climate. One at North Beach, San Francisco, provides salt air conditions; another at Emeryville, an industrial center, affords exposure to smoke, chemical and

*Fig. 4. Paint exposure rack on the roof at Emeryville.*

other fumes and moderate salt air. A third, located at Davis in the Sacramento Valley, is exposed to pure air but rapid and extreme temperature changes.

These racks are wooden frames, the exposure faces of which face south and are set at an angle of 45 deg. with the horizontal, thus affording maximum sunlight, and in this locality, maximum exposure to storms. The face of each rack is 5 ft. wide and the lengths vary from 40 ft. to 120 ft.

These racks are used chiefly for exposing paints on 10 x 16-in. panels of wood, steel, galvanized iron and concrete. The panels are held by inserting the upper end in a galvanized iron spring cap and resting the lower edge on a sill. A raised edge on the sill prevents blowing off. Besides paints, other protective coatings, such as metals, construction materials, etc., are exposed to weathering on these racks.

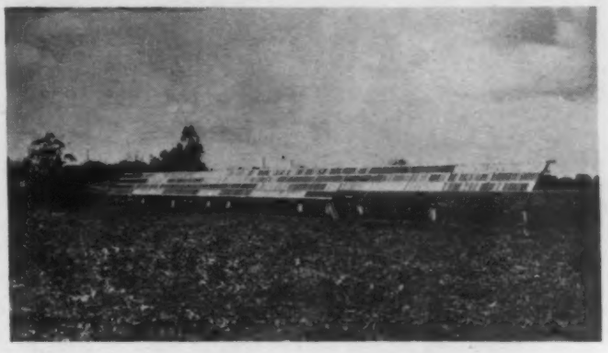

*Fig. 5. Paint exposure rack at Davis.*

*Corrosion Tests—*

*Sea Water Immersion Rack*—A platform has been built between dolphins in San Francisco Bay near North Beach Station. On each side of this platform is a vertical rack to which may be attached panels, pipes or other specimens for corrosion tests by immersion in the sea water. Each frame slides in vertical grooves and may be raised or lowered by a small hand operated winch.

*Acid Tanks*—For corrosion tests by acids or other liquids, two tanks 2 ft. 6 in. x 2 ft. 6 in. x 10 ft. inside have been made of 2¾-in. redwood. Samples are immersed by hanging them from removable, 2-in. diameter, redwood poles, placed longitudinally just below the liquid level.

*Glass Jars*—For corrosion of small samples by electrolysis, glass storage battery jars are arranged in rows with wooden strips across the tops, which serve as terminal boards and suspension supports.

*Moisture Absorption Tests—*

No special apparatus. Glass and metal trays, battery jars and beakers are used, depending on the size of specimens. Weighing is done on suitable balances.

*Chemical Tests—*

A well equipped chemical laboratory is maintained, in which oils, creosote, metals, paints and other supplies may be analyzed.

*Miscellaneous and Special Tests—*

*Pressure Cylinder for Dye Test of Insulator Porcelain*—Tests on chips from porcelain insulators to determine the porosity of the porcelain are made by placing such chips in a steel cylinder and covering with a liquid dye. An accurately fitted plunger, suitably gasketed, is inserted and the whole placed in the testing machine. A pressure of 50,000 lb. per sq.in. is transmitted to the liquid by the plunger and held over night or for several days, with negligible loss of pressure. This apparatus is shown in Fig. 6. The most satisfactory dye is fuchsine dissolved in furfurol. This is noncorrosive and does not cut the oil off the cylinder walls as does alcohol, nor precipitate out as do water dyes. However, it does not keep very well and a new mixture must be made for each test. The color is reddish brown.

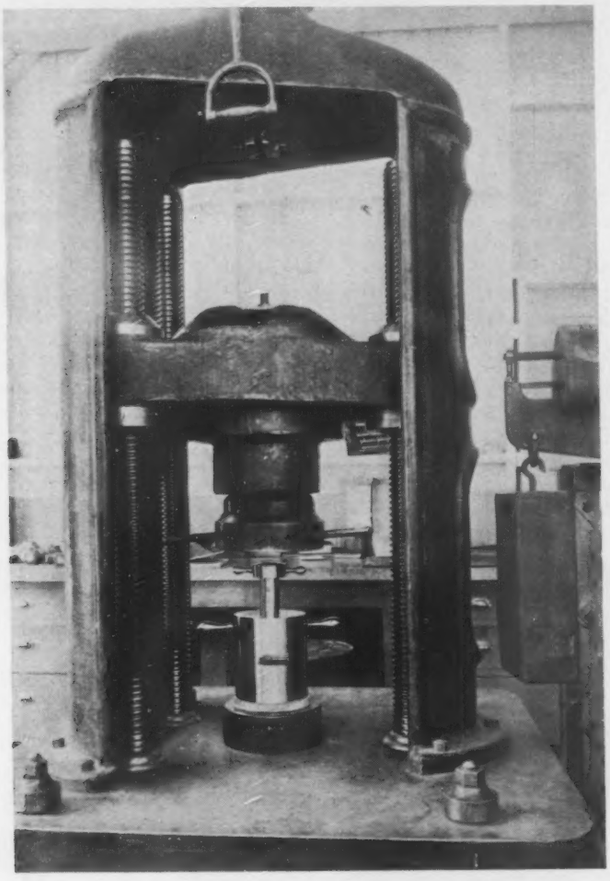

*Fig. 6. Compression clyinder for dye tests on insulator porcelain in place in testing machine.*

## Specifications of Testing Used by the Pacific Gas and Electric Company

*Line Hardware—*

Line hardware is purchased to comply with standard company drawings. In general these drawings represent approved proprietary products as well as apparatus developed by the company. Usually tests are made to check the manufacturer's own guarantees. Special hardware is purchased only on carefully prepared specifications.

*Distribution Transformers—*

These are purchased on yearly agreements with guaranteed average minimum losses, regulations, etc., usually as specified by manufacturer. Tests made include copper loss, core loss, regulation, polarity, heat runs, high potential and radio interference.

*Glass and Porcelain Insulators—*

Insulators for use on lines up to 25,000 volts are purchased to comply with standard company drawings, which in general represent approved proprietary products.

Insulators for high voltage transmission lines are purchased on special specifications and are carefully inspected at the factory.

*Transformer Oil—*

Tests for physical and chemical characteristics are made by the methods given below:

Flash Point—A.S.T.M. Standard D-92-24.
Pour Point—A.S.T.M. Standard D-97-28.
Viscosity—A.S.T.M. Standard D-88-26.
Neutralization Number—A.S.T.M. Tentative Standard D-188-27T.
Mineral Acids—A.S.T.M. Standard D-177-27.
Free and Corrosive Sulphur—A.S.T.M. Standard D-177-27T.
Heat and Sludge Tests—U. S. Bureau of Mines, Bulletin No. 5.
Steam Emulsion Test—A.S.T.M. Standard D-157-27.
Dielectric Strength—A.S.T.M. Standard D-117-27.

Sampling is according to the A.S.T.M. methods given in Standard D-117-27 and Tentative Standard D-270-27T and measurement of quantity is made in accordance with the "Standard Abridged Volume Corrosion Table for Petroleum Oils," A.S.T.M. serial designation D-206-25. All oil purchased is measured, sampled and tested before removal from tank car, drum or other container is permitted.

*Miscellaneous Insulating Materials—*

In general these are purchased on a competitive basis. Laboratory tests according to A.S.T.M. standards, or in special cases, special tests are made on samples submitted. Material purchased thereafter is generally required to be equal in quality to the submitted samples.

*Creosote—*

The sampling and testing of creosote oil used for the butt treatment of cedar poles by the open tank method is in accordance with A.S.T.M. methods, Serials D-38-27, D-168-27, D-139-27 and D-246-27T. Samples are taken from tank cars at destination, or if taken at time of loading, the car is sealed with a company seal.

Tests are made for:

Water content
Matter insoluble in benzol
Complete liquidity and suspended matter

Specific gravity
Fractional distillation
Coke residue
Tar acids
Sulphonation residue
Purity as evidenced by specific gravity and index of refraction of fractions

*Paints—*

After competitive laboratory and exposure tests, paints are purchased as of manufacturers' own formulas. Such paints are required to agree in color, quality and formula with the submitted samples.

*Cement—*

A.S.T.M. standard tests are usually made at the mills by representatives of commercial testing laboratories.

*Poles—*

Most poles purchased are inspected in the forests, when cured and ready for shipment to the company's creosoting plants. Other poles are inspected in dealer's yards, usually after creosoting, in which case inspection covers quality of creosote used and thoroughness of treatment, as well as quality of timber.

All poles are inspected for: Straightness of grain, decay, worm and insect damage, unsound or excessively large knots, scars and "cat-faces," dead streaks, checks, shakes, holes and excessive sweep. They are also checked for length, top diameter, and butt diameter. Count is usually checked after loading, but is subject to recheck at destination.

*Rubber Protective Devices—*

A.S.T.M. standard requirements cover testing of gloves and mats. Manufacturer's guarantee tests are specified on shields, hoods, hose, sleeves, etc., and new goods of first class workmanship and finish required.

All new rubber goods are tested immediately when received. A minimum stock is carried to avoid deterioration in storage. Used material returned for retest is tested and reissued without delay for the same reason.

### Routine Tests and Inspection of the Pacific Gas and Electric Company

*Superficial Inspection—*

*Count and Weight of Material Received*—All invoices of material received are checked as to count, weight or measurement on the basis used in billing. Thus if we are billed by weight, the material is weighed; if by count, actual count is made.

*Use of Gages and Weighing Scales*—In addition to checking the weight of materials so purchased, the scales are used as a check on much material purchased by count, to see that light-weight material is not supplied. This applies to steel insulator pins, pipe fittings, etc.

Wire and cable are weighed as entire shipments, no attention being paid to the weights of individual coils, although large reels are weighed separately, making allowance for tare as claimed by manufacturer.

Transformer oil and creosote are gaged in the tank car, allowance being made for temperature correction. Recheck is made by the gages on our storage tanks.

*Test Shop Inspection—*

*Transformers*—New distribution transformers are received at division warehouse and standard A.I.E.E. tests made on random lots. New power transformers are tested at the factory.

Transformers returned to the central warehouse from company divisions are handled as follows:

The test shop is divided into two sections for convenience, one handling transformers of 40 kw. or less and the other those of 50 kw. or over. Small transformers received are inspected and each marked "Junk" or "Repair," the former being sold or traded to the manufacturer and the latter repaired and stocked.

Transformers of 50 kw. are received, marked "repair for stock" or "repair and return." The latter are handled immediately, while the former are held until needed or worked on in slack periods.

*Electric Meters*—All new electric meters are checked for accuracy, power factor, balance of elements, register ratio and are given a high potential test. They are then stenciled with a company number and emblem. It is the practice to have meters shipped directly to division warehouses by the manufacturer and such tests are made at these locations.

*Switches*—All oil circuit breakers are given a complete test and inspection at the factory. Oil and air switches received at the central warehouse from company divisions are inspected, and if of present standard type, they are repaired and stocked; if otherwise, they are junked.

*Motors*—Old motors are received for credit from divisions, and if less than 2 hp., unless special, are junked. Other motors are tested and a tag put on, telling what repairs are necessary, and then are stored away. When needed to fill an order, a motor is taken to the shop, and the necessary repairs made. Junk motors and those, the cost of repairs on which are excessive, are sold in carload lots to outside dealers.

### Equipment Used for Testing by Southern California Edison Company Ltd.

*Tensile, Compressive and Bend Tests—*

Testing machine, capacity 200,000 lb.

*Dielectric Tests—*

One 3-kva. transformer test set, 0-30,000 volts.
One 200-kva. transformer test set, 0-50,000 volts.
One 100-kva. transformer test set, 0-100,000 volts.
One 100-kva. transformer test set, 0-250,000 volts.

The above are controlled by 100 per cent boost or buck induction regulators.

*Weather Exposure Tests—*

*Laboratory Outfit*—Ultraviolet ray equipment, consisting of 220-volt quartz tube and a revolving drum for testing panels.

*Two Test Racks*—One rack is at the sea shore at Redondo, and the other inland at Gould substation. The racks face south and tilt at an angle of 45 deg. from the vertical.

*Corrosion Tests—*

*Salt Spray Equipment*—Standard type salt spray box. Tests conducted in this box are generally checked by outdoor exposure on a test fence at Redondo.

*Graveyard*—Graveyard located at Somerset substation.

*Moisture Absorption Tests—*

No special equipment.

*Chemical Analysis—*

Complete laboratory equipment for making any kind of chemical analysis.

*Miscellaneous and Special Tests—*

*Complete Electrical Testing Laboratory Equipment*—This consists of: standard indicating and rotating meters, portable meters, potentiometers, resistors, and loading devices, resistance test sets, rotation meters and cycle counters, standard potential and current transformers, Silsbee test set for instrument transformer motor-generator sets for obtaining 60-cycle power and 0-600 volt d.c. power.

*Standard Gage Tester.*

*Oil Life Test Apparatus.*

## Specifications of Testing Used by the Southern California Edison Company Ltd.

*Pole Line Hardware—*

Physical dimensions of the material are checked against standard drawings. The standard also specifies the kind of steel and the galvanizing. The galvanizing is in accordance with our standard No. 21-29, which specifies certain tests. Rejections are made for failure to pass the Preece test, for blisters, for excessively heavy or brittle coating, bare spots and scaly coating.

*Distribution Transformers—*

Each new transformer is tested in accordance with Rule No. 13 of the A.I.E.E.

*Glass and Porcelain Insulators—*

Insulators are given a flashover test. The voltage across the insulator is increased until the flashover occurs; then the voltage is backed down about 5 per cent and held for 2 minutes.

*Transformer Oil—*

The following test methods are followed:

Flash Point—A.S.T.M. Specification D-92-24
Sampling—A.S.T.M. Specification D-117-24
Pour Point—A.S.T.M. Specification D-97-25T
Viscosity—A.S.T.M. Specification D-88-24T
Acidity—A.S.T.M. Specification D-188-24T
Heat Test—Snyder Test, A.S.T.M. Proc., Vol. 25, p. 363.
Corrosion Test—A.S.T.M. Specification D-130-22T.
Dielectric Strength—A.S.T.M. Specification D-117-26T
Unsaturation—Method 550.2 of the Federal Specification Board Spec. No. 20, revised to March 19, 1924
Emulsification—A.S.T.M. Specification D-157-23T
Specific Gravity—A.S.T.M. Specification D-47-24.

*Miscellaneous Insulating Materials—*

Varnished cambric sheets and tape tests made according to "Tentative Methods of Testing Varnished Cloth Tapes," A.S.T.M. Serial Designation D-295-28T.

*Creosote—*

Tests are made by the following standard methods:

Water Content—A.S.T.M. D-38-27 or A.W.P.A. 10c
Insoluble in Benzol—A.S.T.M. D-38-27 or A.W.P.A. 8a
Specific Gravity—A.S.T.M. D-38-27 or A.W.P.A. 18a
Distillation—A.S.T.M. D-246-27T or A.W.P.A. 11c
Float Test—A.S.T.M. D-139-27 or A.W.P.A. 6b
Coke Residue—A.S.T.M. D-167-27 or A.W.P.A. 7b
Tar Acids—A.W.P.A. 26a.
Sulphonation Residue—Forest Service Circular 191.

*Paints—*

We describe to the various manufacturers what our requirements are, and ask them to submit formulas for paints which they manufacture that would meet those requirements. If the formula appears satisfactory, we ask for samples, each sample to consist of two one-quart cans. With these samples, panels are painted and either exposed to weather on the test racks at Redondo or Gould, or, if they are interior paints, the panels are subjected to washing and abrasion tests in the laboratory. Floor paints are tested by applying to a floor and noting how well they wear.

*Cement—*

Tests are made in accordance with A.S.T.M. specifications, by a reliable laboratory, and we are furnished with a certified copy of the test report.

Poles that are treated in our own plant are bored to determine the depth of penetration of the creosote. No tests are made on poles which we buy treated, but we are furnished with charts showing the treatment.

*Rubber Protective Devices—*

*Rubber Gloves*—Tested in accordance with A.S.T.M. Standard.

*Rubber Blankets*—Dielectric test of 20,000 volts.

## Routine Used by the Southern California Edison Company Ltd.

*Superficial Inspection—*

*Count of Material as Received*—The receiving division of our general store is furnished with two copies of purchase orders. One copy shows all the information, but the edge of the second copy is trimmed so that the quantities are removed. The clerk checking in a shipment uses this second copy of the purchase order for his receiving paper. He checks the material against the description shown on the purchase order. He also counts or weighs the shipment, writing the quantity on the copy of the purchase order and showing the date received. Thus it is necessary for the receiver actually to count the shipment and not merely to O.K. a quantity.

The quantity is then compared with the quantity specified on the order and if the shipment is complete, the two copies of the purchase order, with any other papers pertaining to it, are pinned together and sent to the bookkeeping division.

*Weight and Measurement of Material Received*—Covered above.

*Use of Gages and Weighing Scales*—Weighing scales are used in checking in all commodities bought by weight. They are also used in counting a shipment which consists of a large number of pieces, such as bolts or nuts. Here a definite number of the pieces are weighed and the total number of pieces is calculated from the total weight and the unit weight.

In receiving a shipment of a commodity, such as wire, which might consist of a large number of coils, or commodities shipped in standard packages, every fifth coil or package is weighed or counted and the lot computed on this basis.

## Test Shop Inspection of Southern California Edison Company Ltd.

*Transformers—*

All new transformers are given the Standard A.I.E.E. test (Rule 13). The cores in large power transformers are pulled for inspection. Whenever the Megger reading indicates the presence of moisture, the transformer is dried. Special attention is given to oil leaks. On old transformers the dielectric test is lowered slightly but otherwise they are given the standard test.

*A.C. Electric Meters—*

All two-wire meters are checked at 1/20 and 3/4 load, at unity power factor. All three-wire single-element meters are checked at the same loads and power factor and in addition at 3/4 load, 50 per cent power factor. All three-phase meters are checked under actual operating three-phase conditions. They are checked for balance at unity and 86 per cent power factor at 3/4 load and at 25 per cent power factor at 1/2 load. They are calibrated for independence of phase relation. All meters are given a potential test of 1,000 volts between coil and ground.

*Switches—*

Oil circuit breakers are given a dielectric test and the tripping mechanism is checked. When bushing type current transformers are included, these are checked for rating and polarity.

*Motors—*

Excitation values of current and watts are checked at rated voltage. The windings are given a potential test. End play and balance are noted. For new type motors a load test

is run, to determine whether or not they come within temperature limits.

*Insulation Materials—*

Routine dielectric tests are made on insulators taken into stock from old construction.

## Equipment and Test Methods Employed by the San Diego Consolidated Gas & Electric Company

*General—*

This laboratory, called the "test laboratory," is under the management of the shops and stores department, but is equipped and operated for the convenience of all departments and divisions of the company. It is charged with inspections and tests, except electrical tests, on all materials and supplies used for operating and maintenance purposes. All testing is conducted upon the receipt of an approved shop order from the department authorizing the test; blanket shop orders are issued to cover routine tests and inspections.

Supplies and materials are usually purchased on the manufacturer's specifications, and are generally accepted on tests made at the factory or on his guarantee, unless circumstances arise that discredit it. Check tests are frequently made (when directed) on materials and supplies to determine their quality. These tests are made according to standard methods based upon the specifications under which they were purchased.

Some supplies, however, are regularly tested, such as creosote, creosote treatments, rubber gloves and protective appliances, and steel chain and cable, as a safety-first measure.

When new supplies and materials are offered to the company, such as paints, etc., suitable samples, together with the manufacturer's specifications, are furnished this laboratory for testing. After such tests are made, reports and recommendations are submitted to the purchasing department regarding the merits of the material in question. Check tests are frequently made to insure quality of material delivered.

This laboratory is also charged with finding suitable substitutes for various articles of supply, and with investigating new products put on the market that might be adaptable to our needs.

## Equipment Used for Testing by the San Diego Consolidated Gas & Electric Company

*Tensile, Compressive and Bend Tests—*

A tensile and compression machine is used for these tests in so far as is possible. The extent of this testing is somewhat limited, since the machine has a capacity of only 20,000 lb. However, tensile tests are made on copper, aluminum and steel wires and cables, rope, chain, strain insulators, bolts, line hardware, and building materials.

Various methods and adapters have been developed for this machine for making various kinds of tests on materials according to standard methods. Fig. 7 shows a set of stirrups devised for "proof testing" chain.

Tensile tests that are too large for this machine or otherwise do not lend themselves to testing in the machine, are made with a traction dynamometer and improvised means of pulling specimens in the yard.

Compression tests are made on insulators, steel rivets. refractory materials, cement, and building materials, by means of this testing machine.

Bend tests are made in the yard by means of the traction dynamometer and improvised methods of bending specimens, according to the directions of the department requesting such a test.

*Weather Exposure Tests—*

Weather exposure tests on paint are made by painting panels of wood, iron, or concrete (depending on the kind of paint), and placing in an iron rack built at a 45-deg. angle from the horizontal and situated on the roof of our service building, which affords a southern exposure to the sun as well as exposure to fumes and smoke from our gas plant

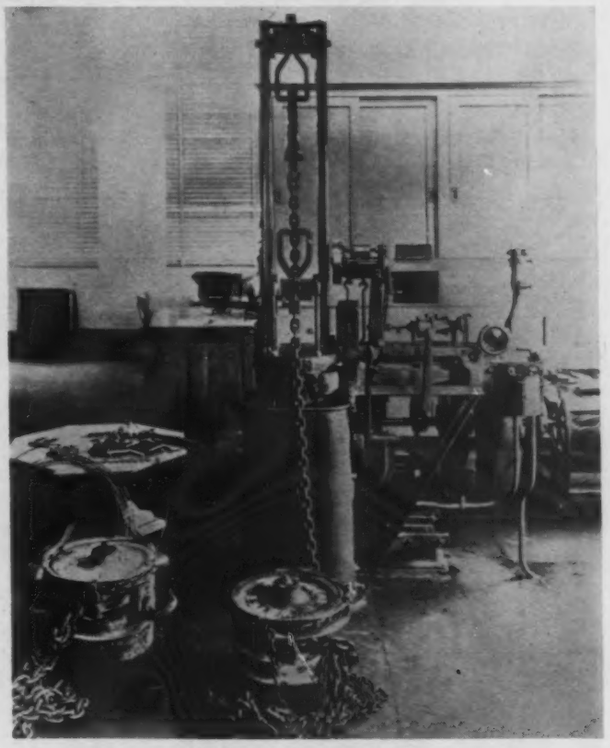

*Fig. 7. 20,000-lb. universal testing machine, showing stirrups which have been developed for chain testing.*

and other industries. Painted panels are also hung on a fence near the bay, which affords a salt air test. Crossarms on poles along the bay region are frequently painted with the paint to be tested.

Weather exposure tests on line hardware are made usually by putting into actual service and inspecting at frequent intervals.

*Corrosion Tests—*

*Sea Water*—This test is made by submerging test specimens in jars containing ordinary sea water, for seven days.

*Acid Test*—This test is made by submerging test specimens in jars containing a 5 per cent solution of hydrochloric acid, for 24 hours.

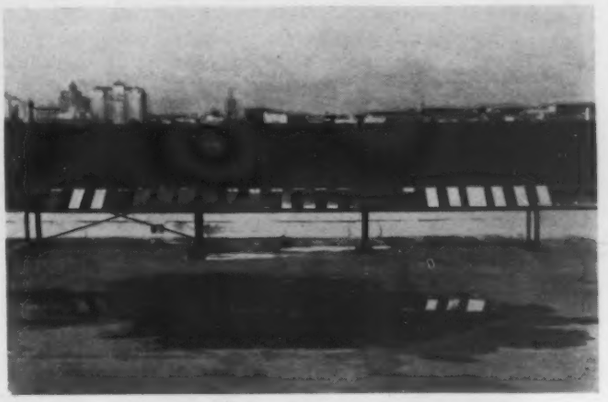

*Fig. 8. Iron rack used for weather exposure tests on paints.*

*Alkali Test*—This test is made by submerging test specimens in jars containing a 5 per cent solution of alkali, usually sodium hydroxide, for 24 hours.

*Acidified Oil*—This test is made by submerging test specimens in jars containing fuel oil, acidified with about 1 per cent of hydrochloric acid.

*Soil Corrosion*—This test is made by burying in corrosive soils, according to a scheme used by the Bureau of Standards.

*Water Absorption Tests*—

No special apparatus is required for these tests. Methods and apparatus are used to meet the requirements of the test to be made. Additional moisture tests are sometimes made with resistance apparatus.

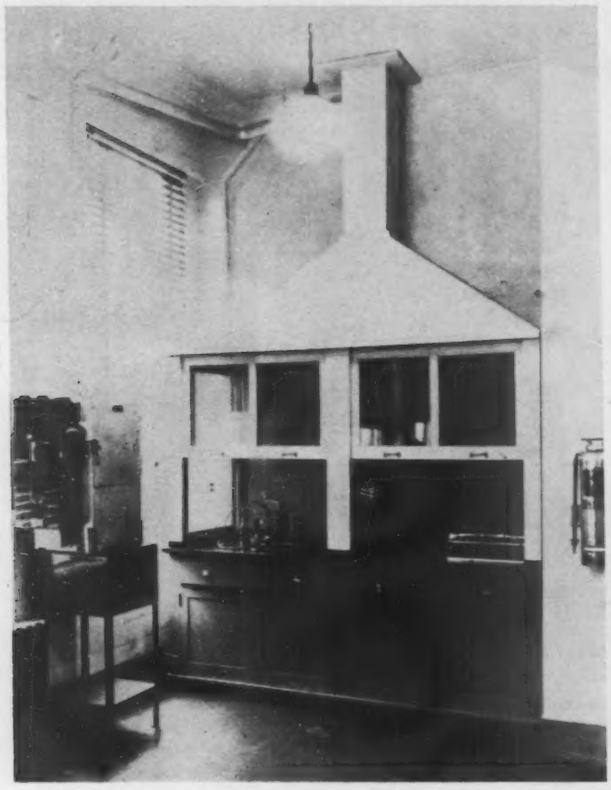

*Fig. 9. Fume hood and oven.*

*Chemical Tests*—

A chemical laboratory is maintained for analyzing oils, creosote, paints, metals, and miscellaneous operating supplies. This laboratory is also supplied for micro-photographic work.

*Miscellaneous Tests*—

*Galvanizing*—This test is made on galvanized equipment and line hardware according to the Preece method and other standard methods.

*Cement*—These tests are made when directed by the engineering department according to the Bureau of Standards methods. Cement is usually accepted on the manufacturer's certificate.

*Creosote*—These tests are conducted according to the A.W.P.A. specifications on each carload of creosote received. Check tests are frequently made on creosote from the treating tanks and storage tanks.

*Poles*—Poles are inspected before and after butt creosoting, according to the N.E.L.A. specifications.

*Paints*—Paints are subjected to tests according to the purpose for which they are to be used. Paints are grouped or classified according to their applications, such as wood surface coatings, plaster and cement coatings, metal surface coatings, hot surface coatings, and protective coatings for burial in the ground. Each of these groups is split up into two more classifications—coatings for exterior surfaces and coatings for interior surfaces. Roof paints might be mentioned as still another classification. Primers are classified in the same manner as paints.

We do not consider it necessary to go into detail in describing our methods of testing paints, as they conform in general to well known standard tests. A special hydrogen sulphide test is considered essential for paints to be used around the plant, especially where the lead content of paint would darken the color of film when exposed to oil smoke and manufactured gas.

Corrosion tests, moisture tests, chemical tests, and microscopic examinations of films and their resistance to weather exposure, are considered by us in selecting and passing on paints.

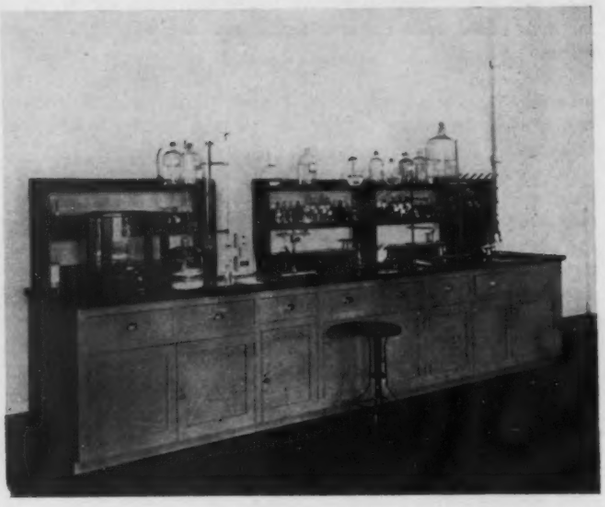

*Fig. 10. Modern bench.*

### Routine Tests and Inspections of the San Diego Consolidated Gas & Electric Company

The routine of inspection in our organization consists of the counting of material when received, weighing and measuring, and gaging and weighing as specially ordered or specified. All electrical material received is sent immediately to the electric repair shop for tests. These materials include the following:

1. Transformers
2. Electric motors
3. Switches
4. Insulating materials.

Any material found to be defective is returned through the storeroom. Routine for shops and stores test laboratory provides that creosote, paints, cements, and miscellaneous materials be tested in accordance with specifications laid down by the various societies of testing materials.

*Fig. 1. Four-story service building, 100 ft. x 200 ft.,with loading platform on north and south side. To the right is garage yard with trucks under marquee. The storeroom occupies three floors, the entire top floor being used for offices, assembly hall and auditorium.*

# *Material Handling Devices**

*This report consists of a series of photographs showing certain types of building and yard facilities, and also such equipment as shelving, scales, trucks, traveling cranes, jib cranes, hoists, and wood boring machinery.*

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* Prepared by Wm. Maddock, G. H. Grummett and F. A. Westrick, as the report of the storeroom buildings and equipment committee, stores division, Purchasing and Stores Section. P. P. Mason, chairman. F. P. Hanson, C. B. Lore, Frank Palmer, F. A. Westrick.

*Fig. 2. Loading platforms. Note the monorail under the marquee the full length of the building. Each of the heavy line construction trucks is assigned a material trailer for hauling material and transformers to the respective jobs. The trucks are stored under the marquee and are unloaded and loaded by the stores force at night. Note springless dial truck scales in lower right hand corner.*

*Fig. 3. Adjustable racks for storing anchor rods, conduit, ground rods, etc. Crossarm rack in back. These adjustable racks are used in pairs; one is independent of the other and the weight of the material holds them in place.*

*Fig. 4. Section of steel shelving in general storeroom. The double-face racks do not have backs, giving more light.*

*Fig. 5. Shipping department. The scale is in the foreground, the shipping clerk's office is the square room in the center and the storekeeper's office is in back.*

*Fig. 6. These rubber-tired four-wheel trucks facilitate the handling of material and save rehandling of supplies put up in advance for shipping or for delivery to construction crews.*

*Fig. 7. Heavy traveling crane used in transformer shop.*

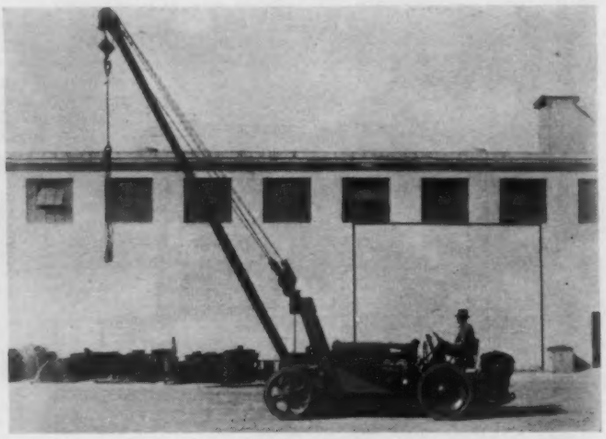

*Fig. 8. Tractor type crane, capacity 5 tons, used for handling machinery and material and the loading of poles.*

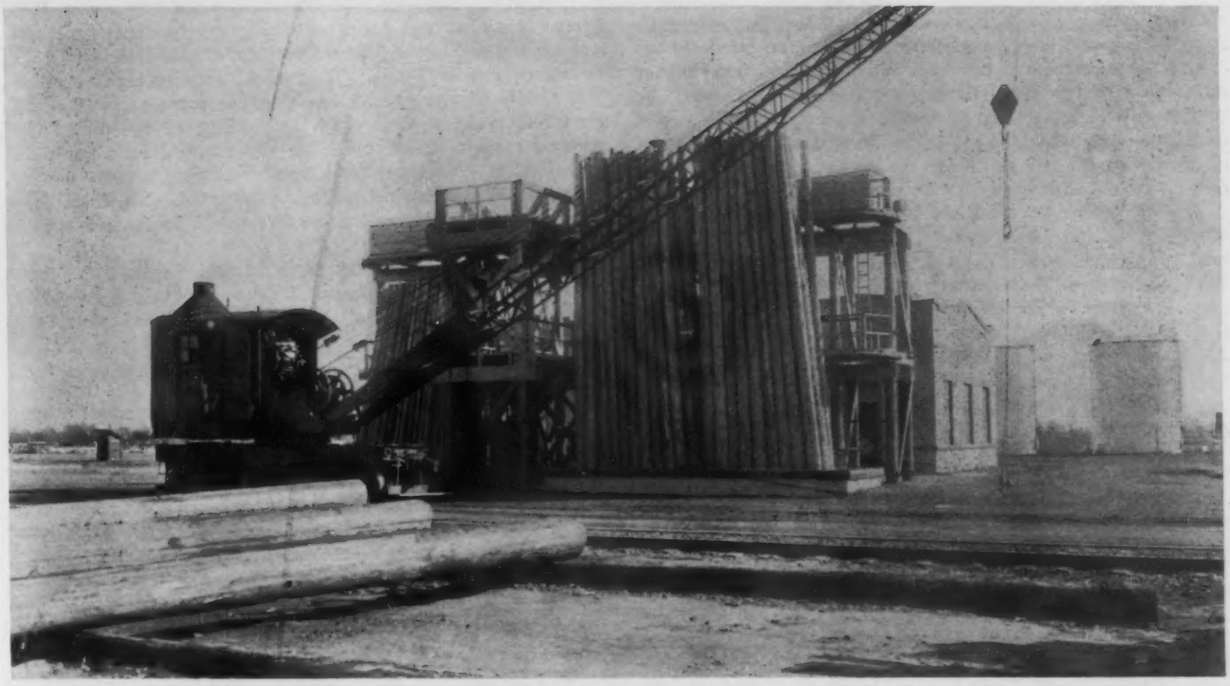

*Fig. 9. Pole-treating plant, showing crane.*

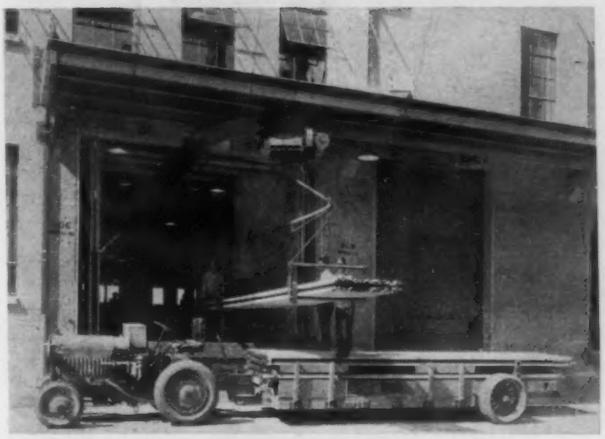

*Fig. 10. Unloading wrapped pipe at storeroom for storage. Note that pipe carrier for handling pipe on channels consists of blocks and channels which are uniformly spaced and locked rigidly. These hardwood blocks have steel pins which interlock.*

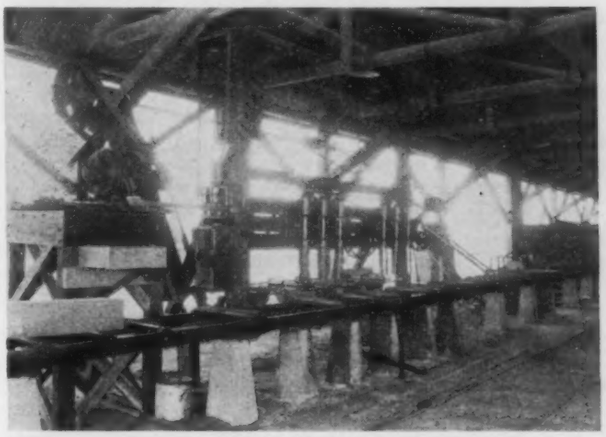

*Fig. 11. A gang drill used in the manufacture of crossarms.*

## *District Stores**

*The purpose of a district store in a public utility is to furnish economically and promptly the material and equipment necessary for conduct of the business with the least expense and delay.*

CAREFUL consideration should be given to the location of the district store. A location in the industrial zone near the center of the district to be served is desirable from the standpoint of the economical mileage of the company trucks and cars covering the territory. A site on or near a main highway should be selected if possible, which will facilitate material deliveries from the general warehouse or from dealers. The store should be large enough to afford ample space for the warehouse, garage, and pole skids. Future development should be considered and allowance made for expansion of the plant. The location of a district warehouse in a residential section is not desirable from the standpoint of land value and also because of the fact that the presence of this kind of industry quite frequently results in an unfriendly feeling arising among the people we are trying to serve.

### Structures

It has been found that the most suitable type of building should be of reinforced concrete, steel frame, with corrugated iron roof and sides, and with concrete floor. It should be large enough to allow for proper housing of the material and supplies, to provide offices for the storekeeping force and operation department, storage space for the material trucks and all company cars, automobile mechanic's shop and wash racks, tool and glove testing rooms, gasoline pump and storage tank, locker rooms, toilets, etc.

For the ordinary district, the construction of an island type 40 x 60-ft. storage platform is recommended, truck-

* Written by H. E. Cox as the report of the committee on district stores, stores division, Purchasing and Stores Section. R. V. Haslett, chairman. H. E. Cox, E. P. Pennebaker, L. A. Prentiss, W. O. Ramage, W. J. Shanahan.

bed height, equipped with a 5-ton chain hoist, 5,000-lb. platform scales, and an oil and paint house constructed on one end of platform to accommodate the storage of transformer oil, paints and other inflammable materials. It may be equipped with motor-driven transformer oil handling and metering equipment. The platform provides for the storage of transformers, oil switches, crossarms, guy wire covers, conduit, wrought iron pipe, wire and cable on reels, etc.

The storage platform should be located within 50 or 60 ft. of the warehouse and situated so as to permit trucks to load and unload from all sides.

The floor level of the store should be truck-bed height or about 3 ft. 6 in. above garage floor. This greatly facilitates the loading and unloading of material to and from trucks. As trucks are stored in the evening, they may be backed up to store platform in front of the issuing windows and doors, ready for the loading of material early the following morning.

### Equipment

The warehouse proper should be equipped with adequate shelving low enough for convenient storing and issuing of material. It has been found that, instead of building bulkheads crosswise in the storeroom floor, the shelving is more convenient when built along the entire side wall, which leaves the entire floor space for the storage of unbroken packages and large equipment. This arrangement is also ideal from the standpoint of lighting, there being no obstructions in the center of the floor. Material on the shelves is always in plain view and store employees, when issuing material, can walk directly to the item wanted.

The following arrangement for the packing and returning of scrap copper, wrought iron, etc., has proved very satisfactory:

> Metal scrap containers are furnished each district store as part of its equipment. In these containers scrap accumulates until a sufficient quantity is received to justify shipment. They are stenciled: "Return to.....(name).....district store when empty," and are handled between the district and general stores without accounting expense. These containers are easily made by cutting the top out of old oil drums or iron barrels.

Warehouse scales of 3,000-lb. capacity or larger should be installed in the floor near the receiving door, making it easy to weigh materials being received or issued. A small counter scale of about 250-lb. capacity may be used to good advantage in weighing small articles or preparing standard packages of material for the line gangs.

One or two issuing windows, 20 ft. in length, are recommended. These should be constructed in the division partition between the garage or truck space and the storeroom proper, the base being a metal covered counter 36 in. high and 40 in. wide. Material may be handled quickly through these windows and such an arrangement prevents workmen entering the warehouse.

### Transil Oil Deliveries

A system of making delivery of transformer and switch oil from the general stores to the district stores by means of an oil tank truck and trailer is being worked to advantage. As the district stores are equipped with a motor-driven oil pump they may be readily adapted to this method of delivery. Much less trouble will be experienced on account of moisture, as shown by the following data:

> Out of 273,100 gal. shipped in drums, 50,900 gal. were rejected on account of moisture in test, or about 19 per cent, while out of 184,615 gal. loaded in tank truck and trailer, only 1,484 gal. were rejected in test or about 0.8 per cent.

There is quite a difference in expense between handling oil in drums and tank trucks. To handle 742 gal. (which represents the capacity of a truck-load of drums) would require drying drums, filling, testing and refilling those rejected, loading on truck, unloading in districts( transferring from drums to oil storage tank, returning empty drums, clerical work necessary in the general store and in the district store to return empty drums. This would require eight or nine hours time of one man. Handling the same amount of oil by tank truck requires only the loading of the oil at the general store and the unloading by motor-driven pump in the district. There being no empty containers, that end of the physical and clerical work is eliminated. The total time required for this latter transaction would be from 1½ to 2 man-hours.

A regular schedule may be arranged for such a tank truck, which will result in district storage tanks being filled regularly on semi-annual blanket requisitions; thus, the necessity of making an order every time oil is needed is eliminated.

### Pole Skids

As stated previously in this article, it is desirable to have storage space for poles on the district store property, as it not only means a saving in time and mileage for the line gangs, but allows the storekeeper to make all issues, resulting in more accurate accounting. Pole skids should be constructed along driveways and elevated to about 3 ft. They should be arranged with the sizes of poles most frequently used in accessible location.

### Stocks Carried and Arranged

A complete line of distribution material should be carried, some of the more important items being: transformers, poles, wire, meters, insulators, crossarms, and pole-line hardware. Stocks are placed on shelves so that the fast-moving items are the most convenient for issuance, but, as nearly as practicable, made to conform to the arrangement in stock ledgers. By ascertaining the quantities of material suitable for line gangs to draw, standard packages may be prepared in advance of the various items and placed on the shelves. This practice is very satisfactory from the standpoint of filling orders quickly, as well as adding to the accuracy of material issues.

### Stock Turnover

The quantities of material and supplies to be carried or "stock control" is one of the most important features of storekeeping. To be able to keep the stocks to the minimum and yet not handicap the distribution forces should be our aim. This can only be accomplished by close co-operation between the stores and distribution forces.

Store stocks should be kept free at all times from surplus, obsolete or scrap items, by making prompt return to the general store. With the general stores set up to care for emergencies and make deliveries within a few hours notice, it is not necessary for a stock in the district store to be carried that will insure against any unusual requirement. To illustrate, some changes in the stores, as well as the operating office, have recently been made in a certain district of one of the member companies and, as a result of the close co-operation between these departments, the stock of transformers alone has been reduced from $7,000 to $4,000. In this particular district it was found that it was not necessary to carry a spare transformer of all sizes to insure against burn-outs or over-load interruptions, but that when such an emergency arises, the general store could make deliveries to the job almost as quickly as the workmen could arrive.

### Accounting

The maintenaince of stock ledgers in the district store is desirable from many angles. It teaches the storekeeper to consider his items of stock as representing so much in dollars and cents, which has a tendency to make him more careful in his material accounting. By making periodical comparisons of his ledger balances with the physical stock, he is in a position to locate errors. His monthly statement to the general storekeeper, showing stock on hand, turnover,

etc., tends to keep him on his toes in this regard, for he knows that if this report shows a healthy turnover, he will receive commendation, whereas if such is not the case and some good explanation cannot be made, he will probably be criticized.

In some of the companies all the accounting work for the district stores is centralized in the general stores department, the district storekeeper maintaining a stock card record showing the receipts and disbursements of material and the balance on hand. Such a record enables the district storekeeper to control his stock, facilitates the proper ordering of material and is used as reference in case of discrepancies with the records at the general stores office.

SUPERVISION

Periodical inspection by the traveling storekeeper, representing the general storekeeper, is necessary for proper supervision and also tends to keep the district storekeepers in touch with the balance of the stores organization.

The traveling storekeeper must have the qualifications to inspire the district storekeepers with enthusiasm for their work and loyalty to the organization, and to promote cooperation with the other departments of the company in the district.

All bulletins pertaining to the work of the district storekeeper and copies of general instructions issued by the management should be sent to the district storekeepers.

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## *Salvage**

*The work of the salvage committee for this year is covered in the following very brief report.*

AT THE committee meetings held during the year, the chairman of this committee submitted an informal report for discussion on the subject of handling second-hand pipe, scrap copper wire, second-hand fittings and obsolete material.

However, these subjects had been so thoroughly covered in preceding papers that no further published report was necessary.

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* Report of the committee on salvage, stores division, Purchasing and Stores Section, E. O. Bullard, chairman. R. E. Fritzer, Fred Hunt.

# STORES ACCOUNTING DIVISION REPORTS[1]

## *Stores Operating Costs**

*This committee recommends to the comptrollers and auditors of the member companies the adoption of a uniform method of segregating stores operating costs.*

REPORTS prepared from a uniform segregation of costs would bring out efficiencies in methods of operating used by some companies, which could be adopted by others.

The following segregation is recommended:

STORES AND WAREHOUSE DEPARTMENT

*Warehouse Labor and Expense*—Include in this account the salaries and expenses of storeroom foreman, yard foreman, order clerks, receiving and shipping clerks, district storekeeper, storeroom labor, storeyard labor, watchmen and messengers.

*Material and Supplies*—This account shall include material and supplies used in connection with the operation of the storeroom and storeyard, such as lumber crayon, fitting sacks, paper bags, drinking cups, etc.

*Maintenance Stores Equipment*—This account shall include the cost of repairing and maintaining storeroom equipment, including movable counters, carts, wheelbarrows, trucks, cranes, hoists, storeroom elevators and monorail systems.

*Water, Steam, Electricity and Telephone Expense*—This account shall include the cost of all water, steam, electricity and telephone service supplied storerooms and storeyards.

*Stationery Expense*—This account shall include the cost of stationery, postage, etc., used by the storerooms and storeyards.

*Transportation Expense*—This account shall include the cost of delivery of material between the general store and district stores.

*Storeroom and Yard Rents*—This account shall include rental of property of others, occupied or used in connection with the stores department.

*Miscellaneous Expenses*—This account shall include miscellaneous items not properly chargeable to the foregoing accounts.

STORES ACCOUNTING DEPARTMENT

*Office Salaries*—This account shall include the salaries and expenses of accountants and clerks employed in stores accounting department.

*Stationery and Supplies*—This account shall include the cost of stationary and supplies used by the stores accounting department.

*Water, Steam-Electricity and Telephone Expense*—This account shall include the cost of such service supplied for the benefit of the supply accounting department.

*Rental and Repairs of Machine Equipment*—This account shall include the rental and repair cost of bookkeeping machines, calculators, adding machines, etc.

*Miscellaneous Supplies and Expense*—This account shall include the cost of miscellaneous small items not properly included in the foregoing accounts.

PURCHASING DEPARTMENT

*Purchasing Department Salaries and Expenses*—This account shall include the salaries and expenses of buyers, clerks, etc., of the purchasing department.

*Traffic Department Salaries and Expenses*—This account shall include the salaries and expenses of the traffic manager and his assistants.

*Stationery and Supplies*—This account shall include the cost of all stationery and supplies used by the purchasing and traffic departments.

*Miscellaneous Supplies and Expense*—This account shall include the cost of miscellaneous small items used by the purchasing department and not properly included in the foregoing accounts.

GENERAL ACCOUNTS

*Supervision*—This account shall include the salaries and expenses of the general storekeeper, his assistants and traveling storekeepers.

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[1] A. A. Charonnat, Pacific Gas and Electric Company, chairman.
Los Angeles Gas and Electric Corporation: N. McMillan.
San Diego Consolidated Gas & Electric Company: G. N. Riblet.
San Joaquin Light & Power Corporation: G. H. Grummett.
Southern California Edison Company Ltd.: F. Palmer.
The Southern Sierras Power Company: A. J. Scott.

* Report of committee on stores operating costs, stores accounting division, Purchasing and Stores Section. A. A. Charonnat, chairman. E. O. Bullard, G. H. Grummett, G. N. Riblet.

*Inventory Adjustments*—To this account shall be charged small items found short in the inventories taken from time to time, likewise the crediting of any overages. In the event that the discrepancy is of any considerable amount, the error should be traced and located and the material charged or credited to the account benefited.

*Obsolescence*—To this account should be charged the difference between the stock ledger value and residual value of material or apparatus removed from stock and scrapped on account of obsolescence.

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## *Material Records**

*This committee made a study of the various material records used by the member companies. Questionnaires were sent to seven of the California utilities and one Arizona utility, and this report is based upon the information recieved from seven of the companies.*

THE conclusion reached from a study of the answers to the questionnaire was that unless there were a great number of individual postings, and unless the posting machines could be used to accumulate information for other departments, the manual method of posting, using visible stock card records, or the "tub" desk card record, would be preferable to machine posting.

### Description of Methods Used.

*Card Record in Tub Desk—*

The card record in the tub desk can be made as extensive a record as desired; some cover all available information and others vary from that down to quantity only, or quantity and amount received, issued and on hand.

In some cases this same record answers as a price card also.

Charges and credits are usually priced, extended and summarized on some form and then posted by hand to this record, various schemes being used to check the correctness of the work performed.

*Card Record in Visible File Cabinets—*

The card record in visible file cabinets follows much the same method, the advantage of the visible cabinet being that when a drawer is opened, quite a number of card headings are immediately in front of the eye. The summary of material issued and received can be made on a fly sheet attached in the same card pocket and either a running balance carried or amounts transferred periodically to the record card. The set-up of these cards is flexible and forms can be made to suit any need.

The principal objection is the expense of the installation and the physical exertion of handling the slides or drawers.

All postings are, of course, by hand.

*Ledger Sheets With Machine Posting—*

Ledger sheets and machine posting can be handled in two or three ways.

A separate price medium seems necessary; also separate warehouse charge or credit slips for each item are required. These charges or credits are priced, extended and sorted, or summarized, then posted. The posting machine will accumulate a total of all postings for checking purposes.

Where a large number of separate items are handled, this makes a great quantity of paper to file and puts additional work on the stockkeepers writing the slips; also, if the individual receiving the material has to sign for it, it holds him longer at the counter. Where a large number of items are issued at one time, there would seem to be a chance that some items would not be written up, or that slips might be lost.

A typewriter bookkeeping machine can be used in connection with a regular warehouse charge, by using a code or catalog number for each item. The code would have to be checked back for corrections, as a transposition of figures or a wrong figure would cause trouble later.

The warehouse charge is coded and priced, then turned over to the machine operator for extension. This operation will not give a printed extension for each item, but prints the total for the slip in the total space and accumulates the totals for the bundle or the day as desired.

While doing this, the machine can make a printed record of such information as desired on a perforated tape, showing code number, job number, quantity, unit price and amount, or any information wanted. These slips are torn apart and sorted by code number, instead of being summarized. Where there is more than one slip per code number, they are fastened together, quantity and amount are footed and marked on the top slip; they then have to be refooted to make sure none are lost or not included in one of the separate bundles. This footing would check against the machine's total. Also, in using the bookkeeping machine, the quantity in the extension has to be typed in the upper keyboard for the recording, and keys in the calculator end also punched for the operation, thus leaving a chance for discrepancy between the figure typed and used for extension, which necessitates another extension to verify. The slips are now ready to post.

This, of course, could be done with any record, as postings can be made either by machine or hand.

This machine can be used to advantage where the making of an invoice is necessary.

*Punched Card Tabulating System—*

The punched card tabulating method also calls for a code number for each stock item. Warehouse charges are coded, priced and extended, and a punched card made for each item. Coding and punching have to be checked and after the results have been obtained in the tabulator, items have to be decoded.

This checking constitutes considerable work and the use of codes leaves a good chance for error; also large storage space is needed for punched cards and unless a vast amount of various information is desired, which this machine is capable of giving, or the machine is put to use by all departments in a company, it proves expensive.

### Comparison

In conclusion, as a comparison, the bookkeeping machine (according to the salesman) will make from 125 to 200 extensions an hour, making the typed tape at the same time. The non-listing calculator operator should make 435 per hour.

A calculator company tells us that on straight ledger postings (no calculations being made) 1,600 hand postings should be made, against 500 per day on a machine.

Pen and ink postings to ledger sheets (date, quantity, amount and calculation), can be made at the rate of 300 to 400 per day. Cards in tub desk can be made at the rate of about 800 and in visible file about 1,200 per day.

With hand posting there are no mechanical breakdowns and no depending on the operator, as nearly anyone in the office can be thrown on the work in case of a rush or sickness of the regular force.

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* Report of material records committee, stores accounting division, Purchasing and Stores Section. G. N. Riblet, chairman. C. B. Lore, M. A. McMillan, H. H. Scoville, E. D. Steele.

### Results of Questionnaire

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| **1. Stock Record Used—** | | | | | | | | | |
| Ledger | .... | X | .... | .... | .... | .... | X | .... | .... |
| Card, tub desk | X | .... | .... | .... | .... | .... | .... | X | X |
| Visible file | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Desk and file | .... | .... | .... | .... | .... | X | .... | .... | .... |
| **2. Method of Posting—** | | | | | | | | | |
| Hand | .... | X | .... | .... | .... | X | X | X | X |
| Machine | X | .... | X | .... | .... | .... | .... | .... | .... |
| **3. Machine Used—** | | | | | | | | | |
| Ellis | X | .... | .... | .... | .... | .... | .... | .... | .... |
| Tabulating | .... | .... | X | .... | .... | .... | .... | .... | .... |
| **4. Have you recently changed from some other system?—** | | | | | | | | | |
| Tub desk to visible record | .... | .... | .... | .... | .... | X | .... | .... | .... |
| Hand to machine posting | X | .... | .... | .... | .... | .... | .... | .... | .... |
| **5. Charges and credits posted direct to record or summarized?—** | | | | | | | | | |
| Posted direct | .... | .... | .... | .... | .... | X | X | .... | .... |
| Summarized | X | X | .... | .... | .... | .... | .... | X | X |
| **6. Frequency of posting to stock record?—** | | | | | | | | | |
| Daily | .... | .... | .... | .... | .... | X | X | .... | .... |
| Weekly | .... | X | .... | .... | .... | .... | .... | X | .... |
| Monthly | X | .... | X | .... | .... | .... | .... | .... | X |
| **7. Approximate number of warehouse charges and credits per month—** | | | | | | | | | |
| 75,000 | X | .... | .... | .... | .... | .... | .... | .... | .... |
| 11,365 | .... | .... | .... | .... | .... | .... | .... | .... | X |
| 9,000 | .... | .... | .... | .... | .... | .... | .... | X | .... |
| 6,500 | .... | .... | X | .... | .... | .... | .... | .... | .... |
| 1,333 | .... | X | .... | .... | .... | .... | .... | .... | .... |
| 1,250 | .... | .... | .... | .... | .... | X | .... | .... | .... |
| 1,082 | .... | .... | .... | .... | .... | .... | X | .... | .... |
| **8. Approximate number of items on slips per month—** | | | | | | | | | |
| 263,000 | X | .... | .... | .... | .... | .... | .... | .... | .... |
| 5,000 | .... | .... | X | .... | .... | .... | .... | .... | .... |
| 33,000 | .... | .... | .... | .... | .... | .... | .... | .... | X |
| 31,500 | .... | .... | .... | .... | .... | .... | .... | X | .... |
| 7,347 | .... | .... | .... | .... | .... | .... | X | .... | .... |
| 6,000 | .... | .... | .... | .... | .... | X | .... | .... | .... |
| 5,795 | .... | X | .... | .... | .... | .... | .... | .... | .... |
| **9. Approximate number of stock items—** | | | | | | | | | |
| 60,000 | X | .... | .... | .... | .... | .... | .... | .... | .... |
| 13,150 | .... | .... | .... | .... | .... | .... | .... | .... | X |
| 12,000 | .... | .... | X | .... | .... | .... | .... | X | .... |
| 3,700 | .... | .... | .... | .... | .... | X | .... | .... | .... |
| 1,943 | .... | X | .... | .... | .... | .... | .... | .... | .... |
| 1,800 | .... | .... | .... | .... | .... | .... | X | .... | .... |
| **10. Records are kept in—** | | | | | | | | | |
| Stores department | .... | X | X | .... | .... | X | X | X | .... |
| Accounting department | X | .... | .... | .... | .... | .... | .... | .... | X |
| **11. Accounting is done by—** | | | | | | | | | |
| Stores department | .... | X | X | .... | .... | X | X | X | .... |
| Accounting department | X | .... | .... | .... | .... | .... | .... | .... | X |
| **12. Do records carry both quantity and value?—** | | | | | | | | | |
| Quantity only | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Quantity and value | X | X | X | .... | .... | X | X | X | X |
| **13. Are records duplicated?—** | | | | | | | | | |
| Yes | .... | X | X | .... | .... | .... | X | .... | .... |
| No | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| **14. Stock record information carried—** | | | | | | | | | |
| All information | .... | X | .... | .... | .... | .... | X | .... | X |
| No purchase data | X | .... | .... | .... | .... | X | .... | .... | .... |
| No serial numbers | X | .... | .... | .... | .... | .... | .... | .... | .... |
| No weight | X | .... | .... | .... | .... | X | .... | .... | .... |
| No location | .... | .... | .... | .... | .... | .... | .... | X | .... |
| No jobber | .... | .... | X | .... | .... | .... | .... | .... | .... |
| **15. Pricing medium—** | | | | | | | | | |
| Stock record | X | .... | .... | .... | .... | X | X | .... | X |
| Price card | .... | X | X | .... | .... | .... | .... | .... | .... |
| Price book | X | .... | .... | .... | .... | .... | .... | X | .... |
| **16. Time of changing price—** | A | B | C | D | E | F | G | H | I |
| At time of paying invoice | .... | .... | .... | .... | .... | X | .... | .... | X |
| Monthly | X | X | X | .... | .... | .... | .... | X | .... |
| Block system | .... | .... | .... | .... | .... | .... | X | .... | .... |
| **17. Is storekeeper informed of slow moving or inactive items?** | | | | | | | | | |
| Slow moving items | a | X | .... | .... | .... | X | a | .... | b |
| Overstocked items | .... | .... | .... | .... | .... | .... | .... | X | .... |
| **18. Any other department informed of the above, or other information?—** | | | | | | | | | |
| Report of slow moving items to department concerned | .... | X | .... | .... | .... | X | .... | .... | .... |
| Money value of each class | X | .... | .... | .... | .... | .... | .... | .... | X |

a By traveling warehouse superintendent.
b On yearly inventory.

### Requirements

The individual requirements of the operating company should determine the method to employ and the type of stock record used, whether a centralized or decentralized record and whether machine or manual methods are employed for its operation.

Irrespective of the kind of record used and the methods employed, it is important from a managerial viewpoint that information in addition to the receipts and disbursements of material and the balance on hand be reflected by these records.

They should show the amount of material on hand at each warehouse or location: for insurance purposes, the amount carried, for emergency uses, the amount of inactive or obsolete items and excessive stocks of active items.

The stock records should be easily accessible to anyone desiring information, but under no circumstances should they leave the office.

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## *Material Invoices**

*Details of procedure in the handling of material invoices are here recommended by the committee. The committee further continues its efforts to encourage the use of the simplified invoice as a means of reducing accounting expense.*

THIS committee recommends the adoption of the following procedure in the handling of invoices for material:

### Recording

The instructions for billing and shipping should be printed on purchase orders or a sticker should be attached to them and the shipper should be requested to send the invoices in duplicate or triplicate, whichever the case may be, immediately to the auditing department. If an invoice is not received within a reasonable length of time, a form letter should be written to the vendor requesting same. We believe that invoices, other than special discount, should not be set up as a liability against the company until such time as they are checked for extensions, correctness of price, f.o.b. point, description, trade and cash discount. After the company has satisfied itself in this regard, invoice should be given a register number, payment to be held until such time as the auditing department is advised of the receipt of material.

The invoices carrying special discounts, if from a reliable firm, should be given a register number immediately upon receipt and voucher issued for payment. If later it is found that an error has been made by the vendor, it may be adjusted by correspondence.

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* Report of material invoices committee, stores accounting division, Purchasing and Stores Section. A. W. Winkleman, chairman. A. A. Charonnat, G. H. Grummett.

### Checking for Prices, Terms, Receipt and Condition of Material

All invoices are referred to the purchasing department for checking of prices and terms. The purchasing department should check the invoices against their price record, which is made up of vendor's quotations, invoices, catalogs, etc. Each invoice is registered on this record, showing the vendor's name and address, order number and date, quantity and description of material, unit price, list price and discounts.

The receipt and condition of material should be made on some form of receiving record issued by the storekeeper receiving the material. This form should show the order number, what the material is required for (stock, resale or some certain job), name of shipper, party receiving and checking the material, the carrier and carrier's bill number, date, quantity received by actual count, weight or measurement (this is determined by the unit by which it is carried on the stock cards), the location of the warehouse, and the warehouse number, if it so happens it is carried by number. If the material is damaged, not as ordered, or defective, notations should be made on this receiving record, giving full details. An inspection report from the carrier should accompany this record in damage cases. A copy of the carrier's bill should also be attached to receiving record.

### Posting to Stock Cards

The manner of posting the invoices to the stock cards after the invoices are approved for receipt and the condition would depend on the system used by the stores department. If posting to the stock cards is accomplished by the use of posting machines, it would be advantageous to post from a tabulating sheet, this sheet to show the invoice reference number, order number, warehouse number, quantity and amount. If posting to the stock cards by hand, each separate invoice should be posted direct to the stock cards, showing the same information as referred to above.

As stated before, a copy of the carrier's bill should accompany receiving records. This bill should show the order number, receiving record number and to whom the bill is to be paid. The invoice department accounts the freight bill to a suspense class, making the notation on the receiving record and freight bill. Upon receipt of the invoice, the amount of the freight bill is incorporated in the invoice price and posted to the tabulation sheet as one amount, an offset being set up in a supense class. If freight is to be paid direct by the stores department, a covering voucher is issued, otherwise it is filed numerically and by carrier's name, awaiting monthly statements from the carrier or a charge from whomsoever paid the bill. Whichever way the charge may be received, it is charged to suspense to offset the credit which was originally given the suspense class. Freight charges on shipments between substores is charged to the cost of operating stores. The hauling charges from the railroad station to the storeroom, should be included in the first cost of material, although in some of the companies such expense is charged to stores operating cost.

### Simplified Invoices

This committee is continuing its efforts in advocating the use of simplified invoice as recommended by the division of simplified practice, U. S. Department of Commerce, as a means of reducing the accounting expense in the purchasing and stores departments.

# STANDARDIZATION DIVISION REPORTS[1]

## *Simplification and Standardization of Material**

*The work of this committee has continued throughout the year, co-ordinating the interests of the engineers, purchasing agents and storekeepers of the utilities with those of the manufacturer, leading to the establishment of definite standards of line hardware items for use on the Pacific Coast.*

A TABULATION was made of the following items of pole line hardware, indicating the N.E.L.A. standards and the various sizes and types used by the eight major companies located in the jurisdiction of the association:

| Item No. | Material | Item No. | Material |
|---|---|---|---|
| 1 | bolts, ½-in. eye | 21 | pole collar plates |
| 2 | bolts, ⅝-in. eye | 22 | pole extensions |
| 3 | bolts, ¾-in. eye | 23 | guy eye |
| 4 | bolts, ⅝-in. carriage | 24 | machine bolts |
| 5 | bolts, ½-in. carriage | 26 | round washer |
| 6 | braces, angle crossarm | 27 | cast beveled washer |
| 7 | braces, flat crossarm | 28 | back brace |
| 8 | clamps, 3-bolt guy | 29 | steel arms |
| 9 | screws, lag—fetter drive | 30 | anchor rods |
| 10 | steps, pole | 31 | anchor plates |
| 11 | Washers, square flat | 32 | ground rods |
| 12 | alley arm brace | 33 | drive points |
| 13 | vertical brace | 34 | drive caps |
| 14 | vertical brace—3-arm | 35 | guy hooks |
| 15 | strain insulator clevis | 36 | marking nails |
| 16 | ⅝-in. double arming bolt | 37 | stubbing washer |
| 17 | guy thimbles | 38 | stubbing bands |
| 18 | Crosby clamps | 39 | break arms |
| 19 | high-voltage signs | 40 | hook bolt |
| 20 | guy wire protector | 41 | wood pin |

Items No. 1 to 24, inclusive, were discussed at the first two meetings, and during the last meeting held in Fresno, the following six standards were definitely established, final approval having been given by the overhead systems committee and the Engineering Section executive committee:

⅝-in. eye bolts
Flat crossarm braces
3-Bolt guy clamps
Pole steps
Square washers
High-voltage crossarm signs.

Blueprints showing the details of these items were distributed to the committee members.

Items No. 25 to 41, inclusive, are to be submitted at the next meeting and further discussion will be held on some

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[1] G. M. Richardson, Southern California Edison Company Ltd., chairman.
California Railroad Commission: C. T. Mess.
Hubbard & Company: C. E. Braun, W. W. Glosser.
Joslyn Company: H. S. Dietrick.
Kortick Manufacturing Company: J. C. Kortick.
Los Angeles Bureau of Power and Light: O. W. Holden, D. P. Nicklin.
Los Angeles Gas and Electric Corporation: E. O. Bullard, F. E. Dillinger, Wm. Maddock, W. J. McCullough.
Maydwell & Hartzell: E. S. Condon.
Pacific Gas and Electric Company: G. H. Hagar, F. P. Hanson, F. R. Sherwood, G. O. Tobey, C. E. Young.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, Wm. de Waard, H. Olsen.
San Joaquin Light & Power Corporation: S. E. Hickman, H. H. Minor.
Southern California Edison Company Ltd.: R. B. Guilbault, E. P. Miller, W. E. Row.
The Southern Sierras Power Company: C. A. Kelley, E. Y. Porter, A. J. Scott.

* Report of the joint committee on simplification and standardization of materials and supplies, Purchasing and Stores Section. G. M. Richardson, chairman; O. W. Holden, secretary. K. B. Ayres, C. E. Braun, E. O. Bullard, E. S. Condon, F. E. Dellinger, W. da Waard, H. S. Dietrick, W. W. Glosser, R. B. Guilbault, G. H. Hagar, F. P. Hanson, S. E. Hickman C. A. Kelley, J. C. Kortick, C. T. Mess, H. H. Minor, D. P. Nicklin, E. Y. Porter, W. E. Row, F. R. Sherwood, J. O. Tobey, C. E. Young.

of the other items, so that definite standards may be established.

It has been unanimously agreed to continue the work of simplification and standardization, extending the scope to other items in general use by the utility companies, when the items listed above have been completed.

Efforts have been made by the committee to enlist the cooperation of other organizations, particularly those of a national character, and, although little has been definitely accomplished in this line, the work of this committee is receiving very favorable recognition throughout the country.

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## *Standard Packages**

*The report of the committee this year covers only the method of packing line hardware.*

IT WAS decided that wooden boxes are preferable to burlap sacks or wooden kegs for packing line hardware. Some members of the committee expressed a preference for a collapsible wire-bound veneer box, and one of the members was in favor of a nailed wooden box with strap iron reinforcement.

The committee was of the opinion that instead of arbitrarily specifying a particular type of wooden box to be used by all the manufacturers, that the specifications for packing, as given below, be followed—all boxes to be reinforced in a manner best suited to the purpose. It is recommended that the quantities of pole line hardware be packed as follows:

| Item | Standard Quantity per Package |
|---|---|
| ⅝-in. eye bolts | 100 |
| ¾-in. eye bolts | 50 |
| Brace, angle crossarm | 5 |
| Brace, flat | 20 |
| Clamp, 3-bolt guy | 50 |
| Screw, lag, ½ x 4-in. | 500 |
| Screw, lag, ½ x 5-in. | 500 |
| Screw, lag, ½ x 6-in. | 500 |
| Screw, lag, ⅝ x 5-in. | 250 |
| Steps, pole, ⅝ x 9-in. | 200 |
| Steps, pole, ⅝ x 10-in. | 150 |
| Washers, square flat | 500 |
| Brace, alley arm, without step | 5 |
| Brace, alley arm, with step | 1 |
| Brace, vertical, 2-arm | 5 |
| Brace, vertical, 3-arm | 5 |
| Bolt, double arming | 50 |
| Bolts, machine— | |
| ⅝ x 4½-in. | 1,000 |
| ⅝ x 5-in. | 500 |
| ⅝ x 6-in. | 500 |
| ½ x 6-in. and up | 250 |
| ⅝ x 6-in. and 8-in. | 200 |
| ⅝ x 10-in. to 18-in. | 100 |
| ⅝ x 20-in. and up | 50 |
| ¾ x 8-in. to 18-in. | 50 |
| ¾ x 20-in. to 26-in. and up | 50 |
| Washers, round ⅜-in. | 5,000 |
| ½-in. | 2,500 |
| ⅝-in. | 1,000 |
| ¾-in. | 1,000 |
| Rods, anchor, ⅝-in. | 10 |
| ¾-in. | 5 |
| 1-in. | 3 |
| Rods, ground, galvanized | 20 |
| copperweld | 10 |
| Hooks, guy | 200 |
| Thimbles, guy, ⅜-in. | 1,000 |
| ½-in. | 500 |
| ⅝-in. | 250 |

* Report of committee on standard packages, simplification and standardization of materials division, Purchasing and Stores Section. E. S. Condon, chairman. E. O. Bullard, W. de Waard, H. S. Dietrick, W. W. Glosser, G. M. Richardson, A. J. Scott, F. R. Sherwood.

# Transportation Section[1]

## ACCOUNTING DIVISION REPORTS[2]

## *Use of Time Clocks For Establishing Shop Labor Costs**

*For the benefit of association members who do not use the time clock system for the recording of time of employees spent on various shop jobs, we have reports from certain members who do use this system and report results as very satisfactory.*

NO COMMENTS are made herein as to the opinions of those not employing the time-clock method, as this report is confined to actual experiences.

Those using this system are very emphatic in their recommendations and some of the salient points brought out through these recommendations are cited herein.

One very important case was decided on a time-clock record involving a claim of excess speed by a heavy truck which collided with a street car in which one man was killed and heavy damage suits followed. The driver had reported on the back of his time card that he had left the job at a certain time. The route of travel was known and substantiated; the time the accident occurred and the time he left the scene of the accident was well recorded and substantiated, and his clock time checking in to the garage was known. All these were of importance, as excessive speeds were claimed by representatives of the street car company. Knowledge of the distance, total elapsed time, the total miles run and the average speed, were all good evidence when compared with actual tests of the maximum speed made by this particular truck unit under power, coasting, etc. Other similar instances have occurred frequently in years past in which the time-clock record played an important part.

The time recording clock is also used on the operator's daily cards, checking vehicles into and out of the garage. This time-clock record has proved its value on a number of occasions in the investigation of collisions, accident claims and various other types of report which alleged that certain vehicle license numbers or company numbers were involved at certain locations at a stated time. The time-clock record sufficiently proved that the vehicles in question had been checked into the shop at a certain time with no subsequent mileage recorded by the speedometers for that day. It was clearly shown that it was impossible for the vehicles to have been involved in accidents at the time or locations as alleged.

Another claim for the time-clock record is that it is a

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[1] Executive committee—E. C. Wood, chairman. V. W. Dennis, vice-chairman. A. Aschoff, secretary. P. H. Ducker, Wm. Fairbanks, S. B. Shaw, C. R. Stanley, J. M. Wainscoat, C. D. Weiss.

[2] H. D. Tisdale, Southern California Edison Company Ltd., chairman.
San Diego Consolidated Gas & Electric Company: H. Fraser.
San Joaquin Light & Power Corporation: D. P. Mason, J. M. Wainscoat.

* Report of committee on use of time clocks for establishing shop labor costs. H. D. Tisdale, chairman.

difficult matter to record incorrect time readings without such a fact being apparent from the reading of the time card. It is difficult to manipulate records, particularly when the time clocks are equipped with synchronous electric movements.

These same clocks are also used for the recording of the time of arrival and departure of the various employees for each day.

To obtain further information, inquiries were made of certain representatives of public garages who reported that the great benefit which they derived from this system was the establishing of records on certain jobs which proved to be convincing factors in settling misunderstandings as to charges made.

Apparently the greatest benefit to be derived from the time-clock system must be in conjunction with a well established job order system and those companies so equipped are securing accurate shop costs.

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## *Unit Costs of Operation and Maintenance of Automotive Equipment**

*Two years ago, a survey was made to determine the advisability of gathering data from association members for the compiling of a report to show comparative unit costs of operation and maintenance of automotive equipment. The majority of members appeared to be anxious to benefit through the publication of such comparative cost data and the committee attempted to complete its study of unit costs, but the subject drifted into a discussion of accounting methods which was not within the scope of the committee's activities, consequently the cost study was left incomplete last year. It is now proposed to pick up the unit cost study from the point of last action and submit a plan to the association members for approval.*

IT IS particularly desirable at this time to bring out the fact that no attempt is being made toward the establishing of a uniform system of accounts or in any manner to touch on general accounting methods. The plan will simply call for certain cost data which can be secured by each member company, from their respective accounts as set up on their books at the present time.

Great efforts have been made to simplify this form by embodying as few units as is possible, yet make the report of some practical use.

Attention is directed to the fact that "Garage Expense" and "Transportation Department Overhead" are combined under the caption of "Garage and Over-all Expense." At the present time, there is an appreciable difference in the grouping of these costs by the various member companies, and it appears desirable to combine these units for the purpose of this proposed comparative study. If at a later date it seems desirable to show these costs in two units, a segregation of charges can be made on a uniform basis and so stated, but for the present study as few practical units as possible are suggested.

A copy of the form in question which is to be used in gathering the necessary cost data, is shown in Fig. 1. It will be noted that it includes the following units of average operating costs per mile: Gasoline, Lubricants, Tires-Tubes Replacement and Repairs; Repairs, sub-total, Garage and Over-all Expense, Depreciation, Total. Following these items are certain operating characteristics:

Average Age in Months.
Average Miles per Month.
Average Miles per Gal. of Gasoline.
Number of Units Involved in Each Group.
Make and Kind of Each Group.

It is proposed that each member company shall furnish the committee the necessary details, from which there will be compiled a report of comparative costs, including all participating companies.

"Repair Expense" shall include the cost of labor and material, painting, battery repairs, proportion of repair shop operation costs, including superintendence and clerical costs and miscellaneous charges for stationery, telephones, etc.

"Garage and Over-all Expense," shall include the salaries and wages of dispatchers, garagemen, cleaners and janitors; the cost of material used in cleaning vehicles including soap, boots, waste, sponges, cup grease, kerosene, funnels and other items of expense incurred in the operation and maintenance of garages; vehicle license fees; taxes and insurance; rents paid for quarters; proportion of administration expense, etc.

The costs are to be reported by groups of various classes of equipment as indicated in a schedule stated herein. This schedule may not include all groups which various companies may have to report but in such a case, the correspondent may include any additional classes of equipment desired, which will be embodied in the comparative report to be compiled by the committee. Any one group should include at least ten units of equipment. Trucks equipped with winch or other devices, the operation of which adds to the unit costs, should be shown in separate classes. The proposed equipment schedule follows:

* Report of committee on unit costs of operation and maintenance of automotive equipment, accounting division, Transportation Section. H. D. Tisdale, chairman.

MOTOR VEHICLE COMPARATIVE COST ANALYSIS
(By Group)

Company Name..... Date.....19....

| Member Company Symbol | Average Operating Expense—Cost per Mile | | | | | | | | Average Operating Characteristics | | | Description | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gasoline | Lubricants | Tires-Tubes Replacement and Repairs | Repairs | Sub-Total | Garage and Overall Expense | Depreciation | Total | Age in Months | Miles per Month | Miles per Gallon Gasoline | Number of Units | Make and Kind |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

*Fig. 1. Form used for motor vehicle comparative cost analysis.*

CLASSES OF VEHICLES

*Passenger Cars*

1. Ford T. & T.
2. Chevrolet, Essex and similar.
3. Dodge, Erskine, Chrysler 52 and 58, Pontiac and similar.
4. Studebaker Dictator, Buick Standard Six, Chrysler 60 and 62, Nash Standard.

*Commercial Vehicles*

1. Ford Express A. & T.
2. Chevrolet Express, Whippet Express and similar.
3. Ford 1½-ton, AA, Chevrolet 1-ton and similar.
4. Dodge and Graham ¾-ton, G.M.C. and Pontiac ¾-ton and similar.

*Trucks*

1. Dodge-Graham 1 to 1½-ton, G.M.C., Reo, Yellow Knight, Willys Knight, Moreland, International, Federal Knight.
2. 1½ to 2½-ton Mack, White, G.M.C., Moreland, Auto Car.
3. 3 to 3½-ton Mack, White, Moreland, G.M.C., F.W.D.
4. 4 to 6-ton Mack, Fageol, Moreland.

NOTE: In classifications of vehicles "similar" means vehicles of like cost, size, wheelbase, etc.

With the approval of this form, a supply will be sent to each association member with a memo of instructions as cited above.

# MAINTENANCE DIVISION REPORTS[1]

## *Equipment for Maintenance and Repairs**

*The maintenance of a fleet of vehicles calls for sufficient equipment to service adequately the cars and trucks in active use. Vehicles temporarily disabled require more extensive tools and supplies. The equipment necessary for maintenance and for the repair shop is here listed.*

THE maintenance department should be so set up that cars coming in at night may be filled with gasoline, oil and water, tires and batteries checked, washed and cleaned, ready to go the next morning or when required.

To accomplish this will require the following items:

*Gasoline*—A filling system delivering gasoline to the fuel tank, metered under pressure, and having a shut-off valve and control at the outlet end of the hose is the first requirement. The underground tank should be of approved make and have a metering device so that deliveries can be checked. A desirable feature is provision for ready access to the foot valve.

*Oil*—Lubricating oils should be stored in convenient tanks, preferably cabinet type, with suitable pump and drain-back device. This keeps the oil free from contamination and prevents waste. A number of swing spout cans of various sizes should be provided to fill the motors.

*Tire Service*—A combination motor compressor and tank providing a working pressure of at least 150 lb. with suitable storage tank or tanks, proper outlets and hose with pressure gages attached. Hose should be long enough to reach the majority of the vehicles in the room. This is best accomplished by air lines along each wall, with shut-off valves and proper outlets.

A tire changer, a tire spreader and a vulcanizing outfit should be furnished, also a tube-testing tank.

*Battery Service*—Water container for distilled water, hydrometers, filling syringes, etc., should be provided. Provision should be made for thorough inspection for corrosion and loose connections. Battery bases should also be inspected.

*Radiator Filling*—Suitable hose with outlet controls, also filling buckets of standard type, should be provided.

*Washing and Cleaning*—A power washer is desirable, delivering water at 300 lb. pressure at the nozzle, suitably installed to take care of drainage and to confine spray to the job being washed. Air connection with hose and booster should be at hand to take care of quick drying. Chamois, tire brushes, fender brushes and wiping cloths should be kept at convenient places. Where closed cars are kept, a vacuum cleaning system is desirable. Polishing materials should also be provided.

*Chassis Lubrication*—Necessary hand and pressure guns should be provided to handle the various oils and greases.

*Minor Repairs*—A work bench with drawers and vise should be provided for use of the mechanical attendant who will make adjustments and small repairs and will also report any major shop repairs needed. This man should have his own kit of mechanics' hand tools.

*Headlights*—This work requires a standard screen and can be handled in connection with the minor repairs. The work bench should be provided with a drawer for various sizes and styles of bulbs.

*Miscellaneous*—Floor jacks, mops, wringers, buckets, squeegees, cleaning compound and drip pans should be used and provision should be made for keeping floors clean and free from grease to lessen danger of accidents.

A desirable feature recommended by the writer is suitable uniforms, white coats for attendants and coveralls for mechanics.

Proper covers of canvas or pantasote should be kept to protect fenders and cushions while cars are being serviced.

*Fire Protection*—Metal containers should be at hand for dirty rags. Fire extinguishers of proper type should be provided.

*Wheel Aligning and Brake Testing Outfits*—These devices are largely in the experimental stage and are being continually changed, therefore operators prefer to send the difficult jobs to some of the recognized specialists in these lines.

### REPAIR SHOP TOOL EQUIPMENT

Shop mechanics should furnish a reasonable amount of hand tools such as several sizes of hammers, large, medium and small screw drivers, a set of end wrenches, small socket set, three or four adjustable wrenches, small Stillson wrench, hack saw, bearing scraper, pliers, cutters and several auto wrenches. These tools should be occasionally inspected for fitness and safety.

Special tools such as reamers, drills, taps, dies, gages, large size wrenches, etc., should be furnished by the company and loaned to the mechanics, being accounted for by a system of brass checks bearing the clock card number of the mechanic.

The tool and machine room should be located close to the foreman's office and should contain the company-owned hand tools and special equipment and the majority of the machine tools. The desirable set-up for the average automotive repair shop is shown under separate headings and will vary according to the nature of repair work contemplated.

*Machine Tools*

These machines should have unit or individual electric drive with necessary guards and safety appliances and be grouped conveniently within the tool room enclosure. For a large fleet of cars the following items are necessary:

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[1] C. R. Stanley, Pacific Gas and Electric Company, chairman. W. J. Schaeffer, Los Angeles Gas and Electric Corporation, vice-chairman.
San Diego Consolidated Gas & Electric Company: R. V. Dodge, C. D. Weiss.
Southern California Edison Company Ltd.: W. H. Bauer, P. H. Ducker, Wm. Fairbanks, E. M. Rondot.

* Report of committee on maintenance and repair equipment, maintenance division, Transportation Section. Prepared by W. H. Bauer, master mechanic, Southern California Edison Company Ltd.

20-in. lathe with long bed.
12-in. lathe with short bed.
Large power drill press.
Small power drill press.
Power hack saw.
Double emery wheel and motor with pedestal.
Electric brake-lining machine with attachments to grind lined shoes to conform to drums.
Multi-purpose valve refacer and reamer sharpener.
Brake drum lathe.
Overhead traveling crane (shop to machine room).
60-ton hydraulic press.
Several electric drill stands.
Piston aligning jig.
Connecting-rod broaching machine.
Metal racks.
Bushing presses, small and large.

Convenient stands for the motor drives for above machines can be made from oil well casing with square boiler plate for tops and bases.

Some of these units will be more convenient if placed on the repair floor.

Various machines for woodworking, blacksmithing, metal working, tire repair and electrical repair work are shown under separate headings.

*Woodworking Machinery*

Shops doing their own body work will find the following machines desirable:

Electric cut-off or swing saw.
Circle saw with unit electric drive.
Band saw with unit electric drive.
Planer and jointer with unit electric drive.
Several electric drills.
Electric screw driver.
Electric nut tightener.
Electric glue pot.
Large and small clamps.
Woodworking benches.
Woodworking vises.
Mitre box.
Square, levels and general woodworking tools.

*Metal Working Machinery*

Blacksmith forge.
Power hammer.
Universal iron worker.
Acetylene welding outfit with tanks, tips and carriage.
Acetylene cutting outfit with tanks, tips and carriage.
Anvils.
Fender tools.
Cyanide pot for case hardening.

*Paint Shop*

Spray guns.
Necessary air pressure system.
Brushes, etc.

*Trim Shop*

Sewing machines.
Cutting tables.
Shears, etc.

*Tire Shop*

Steam or other vulcanizer.
Large tire spreader.
Tube-testing tanks.
Hydraulic jacks.
Air pressure system.
Buffing wheels.
Tire changers.

*Electrical Department*

Electrical test stands and small lathe for armatures.
Battery testing instruments.
Spark plug test stand.
Lead burning outfit.
Battery charger or motor generator set.

*Tool Room Equipment*

Bolt cutters, various sizes.
Various sizes of portable electric drills.
Breast drill.
Small hand drills.
Chain drill.
Large compressed air drill.
Air hammer.
Complete set of taper shank drills, ¼ to 2¾ in.
Complete set of straight shank drills, 1/16 to 5/8 in.
Several sets of number drills, No. 1 to No. 50.
A.S.M.E. set taps and dies, No. 4 to No. 12.
S.A.E. hand taps taper, plug and bottoming.
U.S.S. hand taps taper, plug and bottoming.
Small pipe die set, ⅛ to ½ in.
Large pipe die set, ¾ to 2½ in.
Pipe taps, ⅛ to 2½ in.
Pipe vise.
Complete set of taper pin reamers.
Complete set of straight reamers, ¼ to 2½ in.
Complete set of expansion reamers up to 1½ in.
Complete set of piston pin reamers.
Special reamers as required.
Large socket set, hexagon and square.
Barrel wrenches, various sizes.
Large end wrenches.
Set of water pump wrenches.
Hexagon wheel bearing wrenches.
Octagon wheel bearing wrenches.
Set of metal punches, ¼ to 2 in.
Set of gasket punches, ¼ to 2 in.
Felt cutters, circular.
Glass cutter.
Sets of steel figures, large, medium and small.
Sets of steel letters, large, medium and small.
Stillson wrenches up to 48 in.
Large monkey wrenches up to 48 in.
Air valve grinders.
Electric soldering irons, large, medium and small.
Blow torch and soldering coppers.
Sledge hammers.
Jacks, up to 7½ ton.
Towing dolly.
Towing bar.
Towing chains and rope.
Drop cords with lamps and guards.
Extension cords for electric drills.
Several kinds of gear pullers.
Three-legged pullers, various sizes.
Wheel pullers, threaded, various sizes.
Flange pullers, various sizes.
Wheel pullers with rings and adapters.
Countersinks.
24-in. combination scale protractor and square.
Depth gage.
Set of inside micrometers, 1 to 6 in.
Set of outside micrometers, 1 to 6 in.
Cylinder gage.
Compression gage.
Engine cleaning spray guns.
Surface plate.
Valve lifters, several kinds.
Flaring tools for copper tubing.
Chain hoists.
Step ladders.
Extension ladders.
Pump bucket for "600 W."
Branding irons.
Crank pin turning tool.
Auto creepers.
Set of special Ford A tools.
Set of connecting rod mandrils.
Motor slings and lifting tongs.

*Tool Room Supplies*

Suitable cabinets containing S.A.E. cap screws and nuts.
Suitable cabinets containing U.S.S. cap screws and nuts.
Stove bolts, round head and flat head.
Iron rivets, various sizes.
Hollow brake lining rivets (brass).
Solid copper rivets.
Flat washers.
Cotter keys.
Lock washers.
Emery cloth and sand paper.
Wiping rangs.
Pump packing.
Valve grinding compound.
Hydraulic brake fluid.
Shock absorber fluid.
Penetrating oil.
Graphite.
Liquid glue.
Shellac.
Solder.

Babbitt metal.
Soldering paste.
Soldering acid.
Cutting oil.
Dynamo oil for generators, etc.
Soft annealed iron wire, 16 gage.
Soft annealed iron wire, 29 gage.
Coils of piano wire for springs and choke wires.
Brass shim stock, 0.001 to 0.010.

*Miscellaneous Equipment*

Washing tank with heater and circulating pump.
Steam cleaning outfit.
Greasing rack with pressure guns.

*General*

Order and neatness should be observed that needed tools and supplies may be quickly furnished. A complete inventory should be kept and damaged or unsafe articles should be replaced.

Machine and floor should be kept very clean to minimize accident and fire hazards.

As nearly as possible equipment should be so placed that maximum service can be rendered without unnecessary moving of vehicles.

# BUILDING AND POWER TOOLS DIVISION REPORTS[2]

## *New Garage Layout, Design and Equipment**

*The planning of even a small garage building entails much thought and study. The following presentation of the details of construction of the new three-story and basement reinforced concrete garage of the Pacific Gas and Electric Company may serve to call attention to some features of such a building which might otherwise be overlooked.*

THE Pacific Gas and Electric Company has recently placed in operation a new three story and basement reinforced concrete structure for storing, repairing and maintenance of the large fleet of automotive equipment in the San Francisco division of the company.

An intelligent study of the requirements for a garage cannot be made without considering local conditions in regard to the following points:

(a) Available land or site.
(b) Type of equipment.
(c) Number of pieces of equipment.
(d) Type of work in shop.
(e) Careful study as to whether cheaper to maintain a shop or to farm the work out.
(f) City ordinance restrictions.

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[2] P. H. Ducker, Southern California Edison Company Ltd., chairman.
San Diego Consolidated Gas and Electric Company: R. V. Dodge, C. D. Weiss.
Pacific Gas and Electric Company: E. C. Wood.

* Written by E. C. Wood, chairman, Transportation Section, for building and power tool division.

### Site

The first consideration naturally should be the location. For best results, the site should be selected to fit the building. Usually the contrary is the condition. Much thought should be given to the location from various points of view, for example: proximity to central activities, grade, or slope of the land, size and shape of the building desired, accessibility and cost of the real estate. As a rule, a location which will front on at least two parallel streets or on one street and a service yard will be the most satisfactory and economical with reference to operating conditions.

### Size of Building

The number of vehicles which must be parked in the building should be determined with as much accuracy as is possible, as this will govern the size of the storage area. Also the parking arrangements must be studied in order to utilize the space to the best advantage or, in other words, to obtain the lowest cost per vehicle parked. The automotive equipment should be accomodated comfortably. Unduly close crowding hampers the nightly inspections and increases the chance of damage. At least 12 in. should be allowed between small cars and from 18 in. to 24 in. between trucks. When vehicles are parked at right angles to the aisles, the latter, as a rule, should be as wide as the length of the vehicle facing them. In the case of diagonal parking, they may be proportionately narrower. After the storage section is laid out, plans for the other rooms required for the repair and the service operations should be prepared and combined with that of the storage section. Ample allowance should always be made for expected growth.

### Floors

The building codes generally prescribe that floors must be of concrete or non-combustible materials. In addition, the

*Fig. 1. Exterior view of garage, 19th and Folsom Streets.*

*Fig. 2. Second floor storage—light duty equipment.*

material should be non-absorbent of oils and should be readily cleanable. A special application of top material will prevent absorption. Floors should have plenty of drains and provision for convenient clearing. A good plan is to place drains in the aisles on about 20-ft. centers. In the shop, the desirable properties for floors are that they be fireproof, non-absorbent of oils and readily cleanable. Washroom floors should be waterproof and not slippery. There are many coverings in the market to solve this problem.

### Fire Walls and Sprinklers

The floor area between fire walls in large garages will probably be limited by insurance regulations. The permissible maximum size in garages equipped with a standard system of automatic sprinklers is practically double that of an unsprinkled building. Buildings over two stories in height generally must be protected with sprinklers. It may often be desirable to reduce the areas considerably below that allowed in the regulations, in order to limit the amount of damage to a fleet with consequent interruption to service. In steel bulidings, the cost of the sprinkler system may be somewhat offset by the saving possible through the permitted omission of the fireproofing of the structural steel roof supports, otherwise required.

### Doors

Entrances and exits from the garage must be carefully planned. Every "live" car should face on an aisle or should be parked directly at a doorway. Each aisle should lead either directly or indirectly to a doorway. Since the maximum permissible body width on California highways is 8 ft., doorways should be not less than 12 ft. and preferably not less than 14 ft. wide. The heights of the openings will depend on the company's equipment. They should be at least 2 ft. higher than the highest cab or body. It pays to have doorways of adequate size. Due to size, fire hazard and risk of damage, wooden doors are not generally satisfactory for garage purposes. The single-leaf swing doors are also impractical, due to size. Doors may be selected from the following styles: Sliding, multiple-leaf folding, either vertical or horizontal, or steel rolling curtains. The first two types require suitable trolley hangers and tracks. The greatest objection to the curtain type is that the doors cannot be fitted with sash to add to the natural lighting. Also, unless power-operated, they may be slow in opening and closing. "Fire" doors may be required at all openings and apertures.

### Heating

The method to be provided for heating and ventilating a garage should be carefully considered. In even the balmiest sections of the country, heat is needed during some portions of the year in offices and locker rooms. Steam and hot water are the best heating systems. Heat generating plants should be located preferably in a detached building. If within the garage, the plant should be placed in a separate room used for no other purpose and should be cut off horizontally and vertically from all other parts of the building by reinforced concrete, or masonry walls. Openings in such walls should be restricted to pipe and ducts, and should be made tight in a manner to prevent air passing through walls.

### Air Circulation

Positive recirculation of 1 cu. ft. of air per sq. ft. of floor area should be provided in a garage having an average height of not more than 15 ft. In garages having greater ceiling heights than 15 ft., the volume of air recirculated should be increased in proportion to the increase in height. All fans should be of the non-sparking type.

Natural ventilation may be employed where it is practicable to maintain open windows. The area open should be equivalent to at least 5 per cent of the floor area. Where it is impractical to operate such a system of natural ventilation, a mechanical system of ventilation should be provided. Provision should be made for either the inlet of 1 cu. ft. of air per minute from outdoors for each sq. ft. of floor area, or for removing the same amount and discharging it to the outside, as a means of flushing the garage with fresh air.

### Gasoline Storage and Dispensing

The problem of gasoline storage and handling in large garages has too often been left for the last minute consideration, with the result that an unsatisfactory make-shift has been installed, entailing loss of time and money through delays in filling and wastage from spillage and non-checking in vehicles.

In a garage of a similar capacity to this one, the method of storing and dispensing gasoline is of utmost importance, because of the labor attached to the dispensing of the volume required for the large number of vehicles stored.

The method of fueling used previous to the completion of this garage was by means of portable buggies, and the work was done at night, after all cars and trucks were in their stalls. The method was cumbersome and time-wasting, be-

cause the capacity of the buggies was limited and refills were necessary during the refueling process.

When preliminary plans of the garage were ready, the gasoline handling problem was attacked as a major one, because it was desired to eliminate all unnecessary labor attached to the fueling of trucks and cars. It was also planned to install as accurate and as fast a system as could be had, in order to do away with the fueling of vehicles in their stalls, the idea being that vehicles should be fueled as they came in at the end of the day's work. This was found advisable, because the incoming time of various types of vehicles was staggered fairly uniformly over a period of two hours.

The fueling system in this garage is in two sections. A 2-in. rotary pump, driven by a 3-hp. motor, serves three meter dispensing units on the first floor, and a 1½-in. pump, driven by a 2-hp. motor serves two similar units on the second floor. Each pump draws from two 550-gal. underground storage tanks through suitable lines and valves. This gives a total of 2,200 gal. of storage.

The pumps are protected with automatic bypass valves, so no damage can be done to lines of dispensers by sudden closing of discharge nozzles on the dispensers. On the discharge side of the pumps, 1¼-in. liquid-pressure reducing valves are used in each discharge line, so that each dispensing unit receives a uniform volume and pressure of liquid at all times, irrespective of how many units are open for delivery.

The meter units have a volumetric displacement meter built into them, through which all gasoline is accurately measured.

As each gallon is delivered, a bell rings, enabling the driver of a closed vehicle to note the quantity delivered through audible tolling. Each dial has a totalizing meter built into it, which is shuttered under individual lock and key, and totals dispensed can only be read by the person authorized to do so.

The hose hanger hook, upon which the nozzle of the unit is hung, is a combined remote-control switch and line-valve opening lever. When the hose is lifted from the hook, the hook is raised, which closes the remote-control circuit to the motors of the pump and also opens a valve in the unit, thus permitting liquid to go on through the hose. As these units are wet hose, nozzle-controlled, this is an important feature, as it prevents any pressure upon hose or nozzle in any unit which is not in use at the same time as the one upon which the hook has been raised.

The entire installation was made by the makers of the equipment, with galvanized pipe used throughout. All lines were pitched to the underground tanks and air releases were incorporated in each discharge line immediately after leaving the pumps, so as to eliminate any air which might be drawn by the pumps. The air lines from the air releases were run back to the tanks so that any vapor passing over from the air releases with the air would be caught in the underground tanks. These air releases eliminate the possibility of any air being measured with the gasoline stream through the volumetric meter, with the result that an accurate amount of liquid is dispensed at all times.

Pipe lines inside the garage were insulated with a 2-in. covering of asbestos. This was done to protect the lines against heat in case of fire in a vehicle under them. The method of operating the system is very simple and speedy. As vehicles pull up to the dispensers, located at strategic points in the garage, the driver opens his gas tank and the checker lifts the hose off the hook, raises it, and serves the required amount of gasoline to the vehicle. The checker replaces the hose when he finishes the serving, notes the car number, and places the car number and the amount served on his tally sheet, then resets the dial hands to zero. The driver replaces his tank cap and moves on to his parking stall.

The dispensing units are so placed that a car not requiring gasoline can pass a car being fueled and proceed to its proper parking space without delay.

The gasoline storage and handling system as now operated has done away with labor at night; the fire hazard has been reduced tremendously, and accurate records of fueling requirements can be made when and as required.

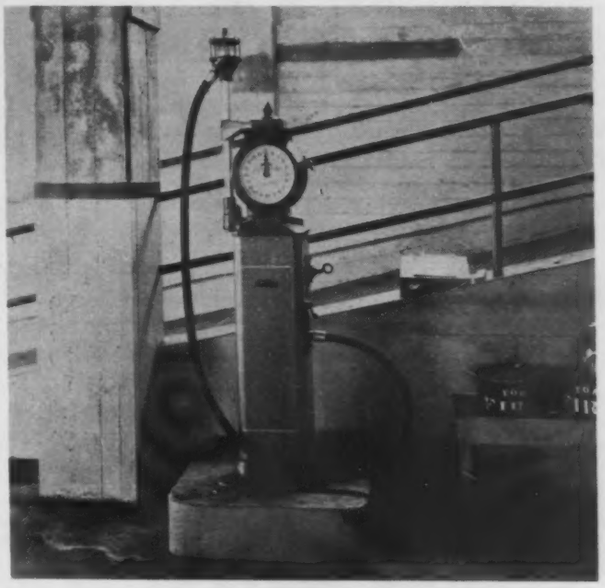

*Fig. 3. Gasoline dispensing unit.*

### Distributing Lubricating Oil

Oiling of equipment does not result in a dangerous fire hazard and can be handled satisfactorily inside the garage. Oiling does not require that the vehicle stand at pumps or at a given location. The work is usually done at night, the oil being distributed from wheel buggies and used in relatively small amounts in each vehicle.

Suitable oil equipment can be provided by purchasing any of the standard makes of storage systems, the size of which depends upon the number and kinds of oil to be carried, as well as the capacity required.

The inflammable nature of these supplies dictates a separate and fireproof storage for maximum protection.

### Locker and Wash Room

Washrooms demand particular planning, both as to arrangement and fixtures. Floors should be waterproof and should slope toward drains. There are many types of stall partitions from which a selection must be made. Likewise there are numerous types of washbasins or their equivalents on the market. In addition to washing facilities, toilets and urinals, all modern washrooms should be fitted with shower baths. Unless some central supply system can be tapped, hot water heaters will be needed. In some liquid soap dispensing systems, if adopted, special built-in features must be taken care of. Also some towel or soap containers, waste receptacles, etc., may demand special construction. Attention should be paid to proper heating and ventilation. Drinking fountains should not be overlooked, not only in the washroom but throughout the plant.

### Stock and Tool Room

Convenient to the shops should be located the stock and tool room. The size will, of course, be governed by the requirements of the shops which are served. In general, steel bins are more desirable than wooden, as they reduce the fire hazard, gain storage space, and are readily altered and

cleaned. Bins should be of ample size to take care of local requirements and should be so located as to be under close supervision. They should be well arranged, with tools of high mortality replacement and those frequently called for in front. A positive mechanical check system should be installed and strictly adhered to in order to prevent lost tools.

Probably one of the most negelected operations of a maintenance shop is the care of tools. Whole books have been written on this subject, and probably some of the information has been remembered and put to good use, but usually small and "just as important" points are overlooked. This is especially true in the care of small tools. They do not involve a big expense, and consequently they are neglected and not given the care that is given larger machines. They soon become defective. In this condition they are ever ready to cut down production and create waste. They are not given the respect of the mechanics, and the tendency is to make a poor tool poorer, if the mechanic received the tool in bad shape to begin with. This results in a new expense, trivial though it may be. These small tools soon mount up into money, not to mention the time wasted in lack of efficiency and in replacements. This expense is usually underestimated and it is not recognized that the money spent on replacements can all be checked back to poor care.

It is well to keep in mind the thought that a clean, perfect tool will go far to establish a degree of efficiency that is irreproachable, while a defective tool will cause inefficient workmanship, and in some cases will destroy the morale of an entire working force.

All tools should be kept clean and free from moisture. They should be stored in a dry, clean space. A wallboard or rack will serve the purpose admirably, and the tool will be in its place when it is wanted. Oil should be kept away from all wood and rubber parts, but a coat of oil is beneficial to all metal parts, if it is wiped clean to keep the dust from collecting.

The most efficient tools are those that are kept in perfect condition. There is less wear on a sharp tool than on a dull one, and it takes less effort to operate a sharp one successfully. If unlimited care is taken of small tools, there will be money saved, not only on tools, but on the time conserved by the increased efficiency they will provide.

*Fig. 4. View of tool room.*

Near the center and to the rear of the garage is the tool-room. Tools and materials are systematically placed here in such a way that there is no loss of time or confusion. It is fenced off with wire, with everything under lock and key, in charge of a tool-room man.

### Repair Shops

In addition to the points previously set forth, which are applicable to the shop section in general, a number of other features will be mentioned. Suitable means should be provided for performing all overhaul and repair operations which are not "farmed out." No attempt will be made to list the machine tools, pits, hoists or cranes, or all of them that may be required. After selection, these may require special attention in the architecture of the building. Substantial work benches should be provided in sufficient number to care for hand work. Regulations generally specify, and correctly so, that repair sections should be separated from the storage section by a non-combustible wall.

The repair shop should be ventilated by mechanical means, providing for inlet and exhaust of 1 cu.ft. of air per minute per sq.ft. of floor area. In connection with engine testing, the engine may discharge direct to the outdoor air through a straight duct or pipe of incombustible material and of suitable size, installed as an extension of the exhaust pipe or muffler, in which case the mechanical system for ventilation may be omitted.

*Fig. 5. Third floor repair shop.*

Each mechanic has his own compartment or working space, with bench, kit of tools, vice, electric outlet for drill, grinder, drop light and safety cleaning can for washing small parts.

*Fig. 6. Machine shop layout—third floor rear. Provision is made for outlet for air and water at each bench.*

Provision is made for an outlet for air and water at each bench. An electric button is handy for an annunciator system in the tool-room.

### Inspection and Repair Pits and Trestles

Elevated trestles, hoists, pits (open-end type) are provided for this service. If pits are used, they should be constructed of concrete or masonry, and should be continuously ventilated by a mechanical system. Pits must be cleaned at least daily, and any accumulation of oil and grease is prohibited. Permanent illumination is provided, as well as a convenient electrical outlet for an extension light. An air outlet is provided for greasing, and an outlet to the tank for waste crankcase oil.

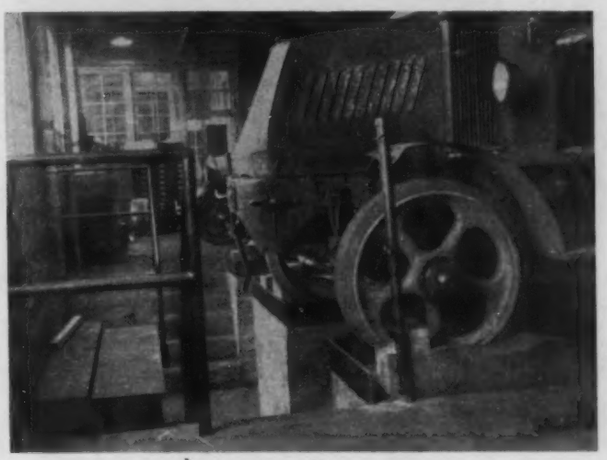

*Fig. 7. Inspection and repair pits and trestles.*

### Paint Shop and Equipment

The paint shop should be isolated from the garage or other shops, at least by fireproof walls. It is important to limit the quantity of paints, varnishes, lacquers and thinners to be stored in the shop. Special lighting units, of a high intensity vaporproof variety are required in safe practice. Ventilation plays an important part, reducing hazards and protecting the health of the workers. The spray or air method of applying paint, lacquer and varnish is gradually supplanting the common brush method in industry. This process, while attended by certain hazards, can be used safely if fundamental precautions are followed. State regulations, local ordinances or insurance rules, all should be carefully followed. The purpose of this discussion is (*a*) to mention briefly the method of spray coating in general use, (*b*) to indicate the posible dangers from a health, fire and explosion standpoint, and (*c*) to discuss methods that may be employed to minimize these hazards.

The hazards of spray coating are, first, that it may cause fires and explosions or second, that it may impair the health of the workers. These dangers usually arise as the result of improper use or failure to provide proper protection. Finishing materials are frequently stored and mixed in the same room, but the quantities in storage should be kept as small as possible. This room preferably should be in a separate building. In general, it should have non-combustible walls, floors, ceiling and equipment. The floor should be waterproofed and provided with a trapped drain to carry all waste to a place where it may be disposed of safely. Openings into the room should be protected, as are openings in fire walls, and exterior doors should have raised sills to prevent the escape of spilled liquids.

Where only a small quantity of finishing materials is kept on hand, it may be stored in approved metal cabinets.

Signs should be posted outside each storage and mixing room to indicate the dangers, and only workers whose duties require their presence should be allowed to enter.

An adequate system of ventilation is an absolute necessity at all locations where finishing materials are stored, mixed or sprayed. This helps considerably to reduce the fire, explosion, and health hazards. Ordinary ventilating methods are not effective. Positive ventilation can be secured only by an adequate exhaust system, which must be specially designed and installed to meet the specific conditions on each job.

There are a number of precautions to be taken. First of all, every effort should be made to prevent fires and explosions. In order to safeguard the health of workers engaged in spray coating, it is advisable:

(*a*) To provide a suitable location for the spraying operation.
(*b*) To provide proper facilities for storing, mixing and handling paints and lacquers.
(*c*) To provide adequate exhaust systems for spraying operations in order that excess vapors and mists may be removed.
(*d*) To provide suitable mask protection for the workers, where needed.
(*e*) To eliminate all possible sources of ignition.
(*f*) To provide suitable fire-extinguishing apparatus.
(*g*) To maintain cleanliness around all operations involving the use of paints and lacquers.
(*h*) To know the health hazards involved in a particular operation and be governed accordingly.
(*i*) In cases where exhaust systems are not provided, or where they do not sufficiently remove the fumes or mists, it is necessary that the workers wear efficient protective equipment.

*Fig. 8. Paint shop and equipment.*

### Air Supply

An adequate supply of fresh air must be admitted to the room from outside sources to allow any system of ventilation to exhaust the mist and vapor effectively. Care must be exercised to make sure that cross currents from nearby windows or other openings do not reduce the efficiency of the system or cause undesirable back drafts.

### Pits and Their Construction

It has been advisable to provide some form of a pit upon which vehicles may be placed and work carried on under the chassis. The length of the pits depends on the type of equipment, such as the wheelbase, etc.

Where one or more pits are required, they should connect into a transverse pit at the wall end. This type of construction eliminates a great deal of climbing in and out of the pits and facilitates ventilation. Permanent lights should be provided in the pit walls, and a convenience outlet for electric drill, etc. Tool racks and work benches are very desirable. Provision should be made for cleaning out the pit, with a drain to sewer.

Where pits are constructed with one end open to an outside wall, either directly or through a transverse pit at the same lower level, natural ventilation is permitted. There should also be a ventilating duct at the closed end of pit. Such ducts shall extend to the outside air and be equipped with a suction fan.

Each of the working pits terminates in a communicating pit or passage. Pits are faced with white paint, and each also has a wall-well light-fitting which projects light into the pit. Entrance to the pit is effected by stairways at each end. Guard rails and wheel stops are provided. Benches at the end of the pit enable the mechanics to make such adjustments as are necessary without having to climb to floor level.

### Washing Facilities and Washracks

In garages of ordinary size, where the floor is suitably drained, vehicles can be washed in their respective stalls. In the operation of a large fleet, this practice is being discontinued.

In larger garages and particularly where it is necessary to wash buses daily, it is more economical to provide other devices more or less mechanical in their operation, either in the garage, in a separate room, or in a separate building.

The body of the vehicle can be cleaned readily by means of overhead and side sprays, or by the use of hot water under high pressure. In some cases liquid soap or other cleansing compounds are used under pressure. High pressure washing is effective. In some cases, steam pressure and air have been utilizied, particularly for the under parts. While the use of a kerosene spray for the chassis gives satisfactory results, it is a fire risk and should not be used in the main garage. A definite washing schedule is a difficult routine to set and abide by, as operating conditions vary so greatly.

Naturally, cleaning costs are an important factor in the operation of a fleet, so the washracks should be laid out with a view to minimizing all unnecessary operations and reducing the time of washing to an absolute minimum.

Four guns capable of producing the pressure stream on the spray are available for instant use. The complete unit occupies one corner of the car-washing racks and is connected to the city water supply.

The covers or gratings on these drains and the top castings holding down the grating should be of heavy construction, to support heavy trucks weighing in excess of 20,000 lb. The floor drainage system should have a suitable size sump and sewer outlet.

*Fig. 9. Washing facilities and washracks.*

### Typical Spray-Gun Operation for Washing Equipment

In smaller garages, the cars may be washed in their respective stalls, but generally speaking, a separate inclosure, properly equipped for cleaning, gives better results.

In making provision for washracks, consider the following: Hoists, trestles or runways, tanks for cleaning solution, heating methods, steam boiler, high pressure washers, overhead washers, illumination of high intensity, vacuum cleaner, drainage, cabinets for storage, hose, boots, sponges, etc.

### Battery Shop

A separate room should be arranged for, in which to charge storage batteries and to make electrical tests. Storage and means of handling acid and distilled water should be provided; plumbing and fixtures should be acidproof, as also bench tops, where batteries are required. Air, water, and convenience outlets must be provided, and ventilation is very important in this department.

*Fig. 10. Upholstery room.*

### Waste-Oil Drainage

A means is provided to catch the oil as it drains from the vehicle, in a large swinging funnel spotted directly under the crankcase opening. It is then stored underground, out of the way, ready to be carted away, with no effort, no slopping pails, no messiness in the pits. This is the real answer to this important garage problem, calling for fewer manhours to do this class of work.

### Compressor Room

Compressed air for inflating tires and for the operation of small machine tools, such as valve grinders, etc., is necessary in a garage. In recent installations there is a complete system for compressing, cooling and storing air, with pipe lines provided with outlets conveniently located at various points in the garage, which deliver air at a pressure of from 125 lb. to 150 lb. per sq.in.

### Piping

Keep in mind the necessity of providing for all the pipe lines which are needed at the present or may be anticipated for future use. Air and water lines are needed, with outlets throughout the working sections, as also drains on waste lines, and steam and condensate returns; gas, vacuum, grease, oil, and hot water should have special pipes to prevent corrosion.

### Pipes in Distinguishing Colors With Shut-Offs Labeled

An identification code for pipe lines was worked out for this building. The colors are strong and clear to facilitate identification, as follows:

Gas line—Yellow.
Cold water—Green.
Hot water—Orange.
Fire lines—Red
Steam lines—White.
Steam return—Black.
Oil drains—Gray.

*Fig. 11. Artificial lighting.*

### Conduits and Wiring

Conduits for the wiring for lighting fixtures, plug receptacles and power circuits should be of more than ample size in order to provide for future loading. Convenience receptacles should be placed at strategic points.

### Artificial Lighting

Good lighting pays. It has been practice to skimp on electrical wiring and fixtures, but it is beginning to be realized that efficient night lighting must be provided. "Efficient" means light free from glare, as well as with intensities up to modern standards.

### Safety in Handling Volatile Liquids

Gasoline vapor may form an explosive mixture with air and due to the fact that this vapor is heavier than air, dangerous fire hazard may occur in a garage unless provision for adequate ventilation is given serious attention.

The careless or unnecessary use of gasoline or distillate or other volatile flammable liquids must be avoided and recognized safe practices observed at all points where the materials are required.

### Fire Equipment

For each 1,000 sq.ft. of floor area, including basements, offices, and store rooms, there should be provided one 1-gal. extinguisher and two sand pails. Extinguishers and pails should be properly distributed. At least one extinguisher and one sand pail should be provided for each oil and grease storage room, and for each gasoline and oil-filling station.

Suitable means should be provided for calling the city fire department. Auxiliary fire boxes should be located on the storage floors. Fire drill should be held frequently, with all the organization taking part.

It must be borne in mind that a fire in a garage will spread quickly. It is not likely, in the event of fire, that many vehicles can be removed from the building, even if the garage is located with exits on one or more streets, and, while the loss might be covered by insurance, the loss of equipment would be a serious handicap.

Another important phase of fire protection is the maintenance of all extinguishing equipment at peak efficiency. Fire extinguishers should be hung or placed where they are most easily accessible and should be frequently inspected to see that they have not been tampered with and are in good condition. Regular recharging is also important. Soda-acid and foam type extinguishers should be discharged at least once a year and recharged with fresh solutions. Carbon-dioxide units do not require recharging until used, but cylinders should be weighed frequently to make sure they have not been accidentally discharged, or have not developed leaks. Carbon tetrachloride extinguishers likewise do not require recharging until used, but should be frequently inspected to see that they are full charged and in working condition.

### Conclusion

The foregoing paragraphs have, without doubt, demonstrated most conclusively that the planning of even a small garage building entails much thought and study, if a thoroughly practical structure be insisted upon. This paper is presented with the thought that it may contain possible reminders of some features which might otherwise be overlooked.

# ORGANIZATION DIVISION REPORTS[1]

## *Training of Motor Vehicle Operators**

*Both classes of drivers, those who use company cars in the course of their other work and professional drivers whose entire time is devoted to this activity, are given a course of training by The Pacific Telephone and Telegraph Company. The details of the course are outlined here, together with methods used by the company to encourage safety and to reward economical and efficient operation.*

SAFE, economical, and efficient operation is the goal of all motor vehicle fleet operators. Safety, of course, comes first—safety to the public, to company employees and to public and company property. Next comes economical and

[1] V. W. Dennis, The Pacific Telephone and Telegraph Company, chairman.
Los Angeles Gas and Electric Corporation: J. B. Prewett.
Pacific Gas and Electric Company: S. B. Shaw.
Portland General Electric Company: H. Drake.
Southern California Edison Company Ltd.: W. H. Brown, P. H. Ducker.

* Written for the educational committee, organization division, Transportation Section, Van W. Dennis, chairman.

efficient operation. This is dependent in large measure upon the operator of the vehicle.

In public service work we are confronted with two problems in the training of motor vehicle operators. First, we have the operator who drives a vehicle incidental to his other work; for example, a repairman who operates a small car with a body built for carrying material. The second group is that of the operators who are employed to operate the vehicle exclusively, such as truck drivers and chauffeurs.

### The Occasional Driver

The first group predominates. This man is a specialist in his line. The vehicle is one of his tools and is used as storeroom and as a conveyance to move himself and the material necessary for his work from job to job. He, therefore, usually looks upon the vehicle as a company tool.

We endeavor to train this class of employee through our drivers' training course (which will be described in detail later) in the following points:

1. He should have a satisfactory knowledge of the company's accident prevention code, of state and municipal traffic requirements, and of his own legal responsibility and liability, if involved in an accident.
2. He is required to have a satisfactory knowledge of the mechanical operation of the vehicle which he drives, its accessories and associated devices, including proper adjustments, minor repairs, proper loading of the vehicle, etc.
3. He must be familiar with the prescribed standard methods and regulations established by the company for the operation of automotive equipment.
4. He must have in his possession a valid operator's license.

### Truck Drivers and Chauffeurs

The other employee is one who is employed to drive motor vehicles exclusively, with the rating of truck driver or chauffeur. Up to the present time this class of employee has been treated in the same way as the first in our training course. We are, however, preparing a routine whereby anyone employed as a truck driver or chauffeur will be required to pass a physical examination as well as one covering his driving and mechanical ability.

It also contemplates a physical examination at two-year periods for this class of employee, and a physical examination for any other driver in our employ who, in the opinion of our motor vehicle inspectors, or safety supervisor, is liable to cause an accident due to his physical condition.

### No Accident Insignia

An employee who has a motor vehicle assigned to him and by careful driving keeps himself free from accidents for a full calendar year is awarded a "No Accident" insignia which is installed on the upper left hand corner of the radiator of the vehicle assigned to him. This insignia states that the employee has had no accidents for one year. Upon the completion of the second year a two-year emblem replaces the first. This plan is followed up three years or more, when the emblem states that more than three years of driving has been completed without a traffic accident. Traffic accidents, with the exceptions noted later, are cause for the removal of the emblem and the driver must complete another calendar year before he is again eligible for another insignia. As the employee is liable to be shifted from one vehicle to another, the insignia is constructed so that it may readily be transferred from one vehicle to another.

For the purpose of administering this insignia plan, an accident over which the driver has no control, such as while the vehicle is properly parked, or while the vehicle is undergoing repairs or where the vehicle is stationary at the direction of a traffic officer or stop lights, and is bumped, is not considered an accident.

### Board of Inquiry for Accidents

All motor vehicle accidents are investigated by a board of inquiry. This board is composed of both management and employee representatives. It establishes the responsibility for the accident and determines whether the no accident insignia is to be removed. If the findings of this board are not satisfactory to the employee, he may within 30 days apply for a reconsideration of the case, when it is again brought up and the employee is notified of the final decision.

All accidents are noted on the employee's personal service record where they may be reviewed at any time.

It is well worth noting that considerably less than half of the accidents are due to carelessness of our employees. The accidents, from a detailed review of them, are minor in nature in the majority of cases.

### Training Course for Drivers

Our training course is not a course for new drivers, but a review for employees who are now driving company vehicles. It has been in operation for two years, during which time approximately 500 drivers have been instructed, with about 300 to take the course in the next twelve months. It was built around our book of "Instructions to Drivers of Motor Vehicles," our "Accident Prevention Code" book and the State Motor Vehicle Act.

Our "Instructions to Drivers of Motor Vehicles" book states on the first page that it is issued to familiarize motor vehicle drivers with the various fundamentals of the correct operation and care of company owned vehicles. It covers fifteen subjects under the following headings:

1. Rules of the Road.
2. Automobile Lubrication.
3. Automobile Brakes and Braking.
4. Steering Mechanism.
5. Automobiles and Pedestrians, Children, Street Cars.
6. Power Plant.
7. Automobile Clutch, Transmission and Differential.
8. Carburetor.
9. Ignition.
10. Radiation.
11. Springs, Frame and Loading.
12. Automobile Lights.
13. Tire Care and Conservation.
14. Automobile Accident Reports.
15. Allowable Maximum Speeds.

A sample of the type of information contained in this book is the following from the chapter on "Automobiles and Pedestrians—Children—Street Cars."

Stop your car—give them plenty of time to get their bearings before attempting to pass them. Where municipal or state laws do not require drivers of motor vehicles to stop during the interval of loading and unloading of passengers from street cars, drive carefully, using good judgment in all cases.

Never under any circumstances allow children to ride or hang onto your machine. Stop your car before ordering them off to avoid accidents.

Drivers should exercise every precaution to prevent accidents to children. If you expect other persons to avoid injuring your children, you should take care not to injure the children of others.

Our Accident Prevention Code book has nineteen pages devoted to motor vehicles, their use and operation. It covers such subjects as:

Responsibility of driver while operating the vehicle (children around schools, on bicycles, scooters, etc.).

Passing on curves.

The handling of gasoline.

The danger of operating a vehicle with over and underinflated tires.

The proper precautions in inflating tires.

How to utilize the motor as an aid to the brakes.

How to crank the motor.

Pictures the correct manner for arm signals.

The care other employees should take while a passenger on company equipment.

Correct parking.

The dangers of traveling on car tracks and the care that should be taken before crossing them.

The loading of material and tools, and the attaching of red flags and lanterns.

The towing of trailers and the use of safety chains with trailers.
The use of air compressors and associated tools.
Power pumps associated with motor equipment.
Pole derricks, winch lines, earth boring machines.
The necessity for protecting traffic while hoisting material, etc.

## Details of Course

The time devoted to the training course is one eight-hour day. The class is composed of ten operators and one instructor, the instructor being an employee trained for this work.

*Introductory*

The first half hour is devoted to an introductory talk by the instructor in which he outlines the purpose of the course and allows the class to get settled and used to their surroundings. The course is conducted by means of questions and answers, and as it is sometimes difficult to bring the backward ones into the discussion, this may call for great diplomacy on the part of the instructor.

*General*

Under the heading of "general," he devotes some time to the subject of how to start the motor, how to drive out of the garage, what to do if the vehicle assigned is not considered by the driver to be in a satisfactory running condition, etc.

*Brakes*

The instructor usually starts a discussion on this subject, such as, which should be used when descending a steep grade, the emergency or the foot brake, or which one wears out the quickest and the reason for the rapid wear. They discuss how to keep the brakes cool when descending a long hill, when to use the motor as a brake, and how, and the distance required to stop a vehicle traveling at different speeds.

*Rules of the Road*

This covers such subjects as what constitutes a highway, arterial highways, the necessity of stopping at arterial stop signs, what is a business district, lawful speed in business districts, passing schools, etc.

*Pedestrians*

This subject covers the question of how pedestrians should be considered in traffic.

*Children*

Particular care is usually given to this subject to impress upon the class that extreme care should be given to children, especially those at play.

*Lights*

When lights are required and why.

*Speed Limits*

Allowable speeds in business zones, railroad crossings, intersections, curves, etc.

*Right of Way*

As the answer as to which vehicle has the right of way in accidents at intersections is still a subject for debate, the instructor consumes some time in impressing upon his pupils that, in case of doubt at crossings or intersections, the other vehicle always has the right of way and that the only right of way, as far as they are concerned, is the safe way. He also brings up under this subject the proper way to park a car at the curb, turning into side streets, both to the left and right, and where it is proper and allowable to make complete turns.

*Hand Signals*

Under this subject is discussed the reason for hand signals and the importance of giving the correct signal at the correct time.

*Passing*

The correct way and time to pass street cars, passing safety zones, the passing of other vehicles moving in the same direction, the signals to give, how much space must be allowed before cutting back, and what should be done when another vehicle wishes to pass you, are all discussed under this heading.

*Drive for the Other Fellow*

The principal points stressed under this subject are: That the other fellow has just as many rights on the highway as our driver has, that if every one respected the other fellow's rights it would cut down accidents, and that courtesy would relieve a good many unpleasant situations and misunderstandings. The other driver may be a green driver and not know what to do, and while our driver cannot control the other fellow, he can control himself. He should not get into a situation where he will have to outguess the other fellow in a hurry, but he should consider that every one, both pedestrian and driver, may possibly be abnormal and liable to do the unexpected. He should be the one who is safe and sane and does the expected thing at the right time. The important points to keep in mind are: "Never let yourself be placed where you cannot have good vision, either from side curtains or from any other cause, and when you look, let it be a good look that will register what you see," "To consider well and quickly, is there any danger?" and "It is better to be safe than sorry."

*Accidents*

The employee is instructed what he should do in case he has an accident. He must first render first aid, if necessary. Incidentally, all of our male employees are required to take first aid training, 90 per cent of them carrying Red Cross first aid certificates.

He must secure names and addresses of witnesses, and draw a sketch of the place where the accident occurred. At this point the instructor usually turns to a demonstration board and sets up an imaginary accident. It has been found that the most practical way to demonstrate these accidents is to designate one member of the class to stage an accident which he was in, or which he saw, and to put it up as a problem to the remainder of the class for a solution of its cause, and the steps which should be taken to avoid a similar one. Or the instructor delegates two members of the class as drivers and the remainder of the class as witnesses.

One of the drivers is then assigned to the duty of making first a verbal report and then a written one on the regular company forms.

On the demonstration board, which is approximately 4 x 6 ft. in diameter, it is possible to demonstrate practically any accident or traffic infraction which is liable to occur in city traffic. Small toy automobiles approximately two inches long are used with this board to demonstrate these accident and traffic problems, six of the passenger car type and three of the truck type. Miniature street cars and "No Parking" signs are also used.

The board is constructed on a scale to allow the placing of four automobiles abreast of each other in the streets with an average margin of space between.

It shows streets both angular and straight, intersections, residence areas, business areas, school buildings, fire hydrants, a fire house, public garage, street car tracks, one-way streets, private garage driveway and other features peculiar to certain areas.

The instructor uses a number of problems to demonstrate different traffic violations and accident hazards. He places the toy automobiles in various places on the board, such as parking too close to fire hydrants, headed the wrong way on a one-way street, driving too fast in a school zone, leaving the vehicle parked with the motor running. The last two automobiles have stickers attached showing the speed and

that the motor is still running. The class is then instructed to pick out the violations.

We consider that the effect and expense expended in putting on our training course is well justified. It is helping our employees to reduce accidents with their private cars as well as to keep our traffic accidents at a minimum, notwithstanding the added traffic congestion in our cities and on our highways.

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## *Prevention of Accidents**

*The thesis of this article is that accidents may be prevented by training drivers in advance to observe good driving habits and by eliminating those with bad driving habits before, rather than after, the accident has occurred.*

NO ONE wishes to become involved in an automobile accident. Even a minor accident, resulting in a dented fender or a broken bumper or two, is a most disagreeable event, subjecting one to argument, explanations, delays and other inconveniences.

Automobile accidents are particularly disagreeable when one is driving another's car. Just that much more explanation must be made and if the car belongs to a corporation, there are the reports to make out and the investigating committee to face. Even if one has been entirely in the right and has not tried to steal the right-of-way or to do any of the other doubtful things, one always feels that he has not quite made the matter perfectly clear to the boss or to the investigating committee.

From the standpoint of the corporation, automobile accidents are even less to be desired. The automobile is a necessary evil anyway and certainly costs enough to run without going out and getting itself in bad with the public by knocking other well meaning cars about the highway and shaking up their occupants, who, by the way, always "are in the right and are careful and considerate drivers." Then one can never tell what an automobile accident will lead to. Quite frequently it may result in a damage suit.

Also, an automobile accident may be a very serious affair, with results that may terminate in death or the crippling of human beings for life.

I do not believe that anyone wants to be involved in an automobile accident. Then how are we to prevent these always undesirable and reportedly unavoidable accidents?

There are several methods that have been used by fleet operators to reduce accidents.

### Penalizing the Driver

One of the most common is that of penalizing the driver who has had an accident or series of accidents. Penalties are varied, such as: lay-off without pay, assessing all or part of the costs of accident, transfer to work not involving use of automobile, or discharge. This, the penalty method, has a salutary effect on the driver who has the accident and to a lesser degree on his associates. Of itself, however, it does not tell the driver or his fellows how to avoid future accidents.

### Safe Driving Award

The award method is the converse of the penalty method. Under this method drivers are rewarded for not having accidents. There are several ways of carrying out the award method, most common of which are: by giving badges or insignia, by awarding bonuses, by giving extra days off or extra pay, by promotion and so on. This method is sometimes applied in connection with the penalty method. It is quite popular with many operators of fleets of trucks, taxicabs and buses. It is believed to be effective for the reason that it gains the interest of a greater proportion of the drivers than does the penalty method. When one driver is penalized for an accident most of the other drivers say to themselves, "I would never have an accident like that. I am always careful." But under the award method, the drivers become interested in earning the award, whatever it may be, and, in thinking of that award, endeavor to make careful drivers of themselves. Thus a greater proportion of the drivers are affected.

### More Care Needed

We started with the proposition that no one wants an accident. Yet they happen.

An analysis of any group of records of automobile accidents will reveal that a very high percentage of such accidents could have been avoided by some very slightly different action on the part of the driver, or, where two cars were involved, by either one of the drivers. By slightly different action we mean a little less speed, or a little more clearance, making a little more allowance for what the other driver might do, a little more care in making a left turn, or a little more care in making signals. The difference between an accident and no accident is usually just "a little" of something.

To our way of thinking, after analyzing these accidents, all that is needed is just a little mo e care.

Human beings are creatures of habit. Most of our physical movements are performed without thinking. We sometimes eat a full meal without even knowing what we have eaten. Some people who play the piano can talk about the weather, without missing a note while so doing. Some automobile drivers can drive on a crowded highway and look at the passengers in the back seat at the same time, without having a collision—until they have one.

### Teaching Good Habits

It is a mere novice who must stop and think before he shifts gears, operates clutch or brakes or turns the wheel to negotiate a corner. All this is a matter of habit and reaction.

The trouble is that too many drivers have bad driving habits. It is the driver with bad driving habits who indicates a left turn when he means a right turn, or gives a stop signal when he intends to turn left. It is the driver with bad driving habits who never blows his horn when he overtakes another car. Other common bad habits are: driving in the center of the road, disregarding "slow" signs, excessive speed around corners, cutting over to left on curves, and making turns with delayed signals or no signals at all.

This being the case, the way to prevent accidents is to teach all drivers good driving habits. For the operator of a fleet, it is still simpler—either teach all of the fleet drivers good habits or select only such drivers as have good habits. If the drivers have already been selected, it will be necessary to train them, or eliminate those that have bad habits, but in any event it is better to do so before they have accidents than afterwards.

### Supervision Required

The teaching of good habits to drivers or discovering those that have bad habits will require supervision. Most of the drivers are out on the road all day without any supervision. Most other hazardous occupations are closely supervised, and workmen with bad habits are taught good habits or eliminated.

It is our conclusion that the most effective method of reducing automobile accidents that can be employed by a fleet operator is to obtain drivers that have good driving habits, to teach good habits to those who have bad habits and to eliminate those who cannot be taught, before they have accidents, if possible.

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* Written for the educational committee, organization division, Transportation Section, by S. B. Shaw.

# *Handling Material by Truck From the Company's General Storeroom**

*The procedure of handling material by truck from the general storeroom as it is in effect on the system of the Southern California Edison Company Ltd. is here described.*

THE time may be assumed to be any week-day, the place the Southern California Edison Company Ltd. general store at Alhambra.

At 4 p.m. the telephone in the office of the truck master rings and is answered by the truck dispatcher. The foreman of the shipping room is calling to place orders for transportation equipment for the following day, also to inform the truck dispatcher that there may be trucks loaded preparatory for an early delivery to some of the many district stores or construction jobs.

The shipping room foreman reads the list of loaded trucks by their equipment number, giving the destination and the time the material is wanted on the job, then makes request for transportation for other materials in the shipping room, by tonnage and destination as follows:

| Truck No. | Trailer No. | Capacity | Loaded for |
|---|---|---|---|
| 2491 | A 90 | 10 & 5 | Visalia General Store |
| 1729 | | 10 | Long Beach |
| 1678 | | 3 | Ventura at 8 a.m. (rush) |
| 2777 | | 3 | Monrovia |

3 tons of materials for Covina.
3 tons of materials for Pomona, transmission line job, to be delivered in field.
3 tons of materials for Alhambra district store.
3 tons of materials for Pasadena district store.
4 tons of material for Redondo district store.
4 tons of materials for Laguna Bell substation construction job.
4 tons of materials for Ventura district, transmission construction job.
5 tons of materials for Santa Monica district store.
11 tons of materials for Redlands.
9 tons of materials for La Fress substation construction job.
16 tons of materials for Long Beach district store.
5 tons of materials for Huntington Beach district store.
10 tons of materials for Santa Ana district store.

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* Report of committee on handling material by truck, organization division, Transportation Section. W. H. Brown, chairman.

*Fig. 1. Service recorder, a device by which the operating time of the truck is automatically recorded. See Fig. 2 for history of this vehicle.*

The truck dispatcher then assigns the necessary equipment, and the number of the truck to handle these amounts of materials, combining two or more destinations on one truck or truck and trailer whenever possible. In the above cited case, for instance, Huntington Beach and Santa Ana would be combined on a 10-ton truck and 5-ton trailer.

The truck dispatcher places a memo order on the driver's dispatch board for each regularly assigned driver, showing destination for following day. This information enables the driver to plan his home affairs accordingly. Also this procedure expedites the departure of the trucks from the garage in the morning.

The trucks are equipped with a "service recorder," a device which automatically records on a chart when the vehicle is running or stopped. Each driver changes the chart for this recorder each morning before his departure from the garage for the shipping room.

### From Shipping Room to Destination

Each driver reports to the foreman of the shipping room at 8 a.m., informing him of the trip to which he has been assigned. The shipping room foreman has segregated the requisitions and material orders for each destination and has listed them by serial and file numbers on a form prepared for this purpose. He also shows on this form the nature of the articles, as: 1 bag, 2 bundles, 1 box, etc., together with the scale weight of each piece, also the total weight of the load. The requisitions are given to a checker and loading crew and the above mentioned form is given to the truck driver, who then checks his load as it placed on the trucks. He receipts for the number of pieces and is held responsible for the material until he obtains the signature on this form of the district storekeeper, field clerk or construction department material clerk, as the case may be. This has proved very satisfactory, as it immediately places the responsibility for any lost material, slight though our experience has shown this loss to be.

The copies of the requisitions accompanying the materials are given to the truck driver, who in turn delivers them to their destination with the material, where it is rechecked by the storekeeper and receipted for. In case of a shortage, a notation to that effect is made on the form retained by the driver and the regular "Over, Short or Damaged" report made up later by the district storekeeper and forwarded through the regular channels. When investigated at a later date, the form returned by the driver, which is filed by serial number, is used as a cross reference and decision made as to where responsibility lies.

The above method has proved to be a very satisfactory way to handle our materials, both from the viewpoint of celerity and the reduction of lost materials.

SOUTHERN CALIFORNIA EDISON COMPANY LTD.
TRANSPORTATION DEPARTMENT

Speedometer Reading
IN 62549
OUT 62418
Total 131

**DAILY TRUCK REPORT**
MAIN GARAGE COPY

Date Jan 28 1931
Driver B.E. Myers Truck No. 2105 Trailer No. ..... Car Capacity ..... Tons

| TIME ARRIVED | DESTINATION | TIME LEFT | MILES | WEIGHT | TRANSPORTATION CHARGE |
|---|---|---|---|---|---|
| 7:55 | Garage | 8:00 | | Empty | |
| 8:00 | Sup. Store | | | 11 | |
| | Loading | 10:35 | | 12000 | 1642-A |
| 1:42 | Alm Substation | | 55 | " | |
| | Unloading | 3:22 | | 10000 | |
| 4:25 | Redlands | | 11 | 8000 | |
| | Unloading | 5:22 | | " | |
| 5:45 | Colton Sub | | 10 | Empty | |
| | Loading | 5:55 | | 4200 | 803-B7 |
| 1:52 | Garage | | 55 | " | |
| | | | 131 | | |

*Fig. 2. Daily truck report of the same vehicle whose chart is shown in Fig. 1. This is filled out by the driver and handed in at the end of the day.*

The driver has a daily report to fill out which shows his name, truck number and date, also starting and ending speedometer readings for the day. This report is a log of the driver's daily activities and shows the weight of materials for the various destinations, also the general work order number or account number for which the material is intended. This enables the accounting section of the transportation department to make an equitable distribution of the costs charged to the various accounts or work orders on their reports prepared monthly and forwarded to the auditor.

### Load for Return Trip

The materials on hand in a district store or at any substation, transmission or construction job which are dismantled, obsolete, in bad order or not required are so listed on a form which is compiled by the storekeeper or material clerk from information furnished by the district foreman or other constituted authority. These are sent to the general store requesting disposition. If approved for return to the general store, the form so approved is sent to the foreman of the shipping room, who gives it to the first truck driver going to that location and it so becomes an order to pick up this material.

The drivers are anxious to obtain these return loads, as they know that by so doing they increase the ton-mileage for the truck they are driving, and reduce the ton-mileage cost, as for example: A 5-ton truck with capacity load travels 70 miles to its destination, or 350 ton-miles. If a return load of 3 tons is obtained, the ton-mileage is increased 210 ton-miles, or a total of 560 ton-miles for the trip, whereas if the truck returned empty, the ton-mileage would be one-half of of 350 or 175 ton-miles for the trip.

The delivery and return of poles is handled in the same manner, save that, due to special equipment needed on the trucks and pole trailers, the same vehicles are used each day on this particular class of delivery.

All substation equipment which exceeds the width, height or weight limits prescribed by state, county or municipality is delivered on special low bed trailers drawn by winch-equipped trucks, after we have routed and obtained the necessary permits, and in some cases, routings from the various city and county offices concerned.

### Ton-Mileage Cost

The following figures will tend to illustrate the tonnages handled and ratio of cost for capacity ton-mileage to actual ton-mileage. We are handling approximately 150 tons per day, 25 days per month for a monthly average of 3,750 tons. We also handle approximately 1,000 tons of poles per month for a grand total monthly average of 4,750 tons. Our possible average capacity is 6,000 tons, so that we have an average of slightly more than three-fourths capacity loads for every mile traveled, giving the resultant ratio between capacity ton-mile cost and actual ton-mile cost of 4.75 to 6.

### Loading and Repairs at Night

When the truck driver returns to the general store after delivering a load of materials, he turns in his receipted papers and then the shipping room foreman loads the truck for one of the next day's early deliveries and sends the truck to the garage for the night.

The truck driver makes out the aforementioned truck report, then fills out and signs a form trouble report, giving the truck number and a list thereon of any mechanical troubles experienced during his trips for the day. The necessary repairs or adjustments are made by the crew of mechanics who work at night, coming on duty at 4 p.m. and remaining till midnight, provided the repairs are completed; otherwise they remain until completion, for all equipment, unless requiring major overhaul, must be available for service the next morning.

FORM TRANSPORTATION 7. 300 PADS 8-30
SOUTHERN CALIFORNIA EDISON COMPANY

**DRIVER'S TROUBLE REPORT**

.....193.....

.....Driver

Note trouble in detail .....

Time Lost Due to Defective Automotive Equipment .....

**MECHANIC'S REPORT**

.....193.....

.....Mechanic

Auto No.....

*Fig. 3. Driver's trouble report which is filled in at the close of each day and which provides both a guide and record for the work of the repair department.*

By this system both the delivery of materials and maintenance of equipment has kept pace with the growth of the organization, permitting a greater monthly volume of business in the district stores without necessitating an increase in their idle stock on hand. At the same time all necessary data are provided for accounting purposes in this department.

# TECHNICAL DIVISION REPORTS[1]

## *Materials and Supplies**

*This report contains a summary of the experience of member companies in the use of materials or supplies which may be of value to others having similar problems. The use of an aluminum alloy for a test body, pressed wood for cab tops and door linings and various considerations in regard to lubricants, fuels and brake linings, are included in the report.*

UNDER the classification of body materials, the committee on material and supplies has to report that one of the member companies has constructed a test body using an aluminum alloy for the body members, in-

[1] S. B. Shaw, Pacific Gas and Electric Company, chairman.
Pacific Gas and Electric Company: Wm. McGuire, J. S. Moulton, C. R. Stanley.
Southern California Edison Company Ltd.: C. O. Hutchins.

* Report of the committee on materials and supplies, technical division, Transportation Section. S. B. Shaw, chairman.

cluding the cross members, the framing for the side racks, tool boxes, and practically all of the body. In constructing the body, the specifications and recommendations of the manufacturer have been followed with respect to the best aluminum alloy for the purpose. The particular body constructed has been assigned to severe conditions in the mountains at a location where there will be a minimum of corrosion, because it will be well removed from the sea air. In connection with this body, an aluminum pole-setting derrick has been designed, with a reduction in weight as compared to a steel derrick of 30 to 40 per cent. Certain parts of the derrick, such as the sheave pins, sheaves and derrick head and side member ends are being constructed of steel. The alloy will weigh less than 300 lb. for a standard three-leg type derrick, which will handle 45 to 50-ft. poles. After a year's service, this company will be able to give a further report on the way in which such a body will stand up.

### Further Body Materials

Further, in conection with body materials, some experimental use has been made of pressed wood for the tops of cabs, tops of canopy and bodies for commercial vehicles. Recently some experiments were made with this material for the lining of doors on Model "A" Fords, using it in place of the cardboard lining, which does not seem to stand up very well.

The committee thinks there may be some possibilities in the use of anti-corrosive steel for body work and certain other special work around vehicles, but so far as we know at the present time, nothing has been done in this field.

### Lubricants

One of the member companies is preparing a chart or table to show the general recommendations of the several different manufacturers of oils and greases with respect to the use of their products for various purposes. There are several different types of grease with various soap bases, as well as the straight mineral oil products, so the committee is working on a chart which will show what the various companies recommend for various purposes.

In connection with the crankcase oil lubrication, it has recently been brought to the attention of the committee that some care must be exercised in mixing different brands of western oils. As an example, it has been stated that one type of western oil cannot be mixed with other western oils in crankcases on account of the tendency to congeal or emulsify.

### Fuels

One of the member companies is making some investigations of the relative efficiency of different types of fuels, including natural gasolines and several classes of blends, as well as the gasoline containing Ethyl fluid. An indicating fuel rate flow meter has been developed which will expedite the investigation.

### Brake Lining

The latest report on brake lining is that, for internal brakes of the two-shoe type, molded shoes seem to give the best results, both in respect to reduction of the amount of adjustments required, uniformity of braking action under various conditions and minimum scoring effect on drums. The manner of applying these linings is quite important. Several of the users have found that it is desirable to relieve the lining for a considerable distance back from the heel. This is evidently desirable for the reason that it lessens the likelihood of extremely high inner pressures at the heel point with consequent distortion of drums. A firm woven lining containing a certain amount of zinc wire has recently been developed.

### Top Dressings

The committee has not much information on top dressings so far but reports some difficulty in the use of one type of dressing, due to the difficulty in getting it to dry properly. The asphalt type of top dressing seems still to give the same trouble of chalking, as previously reported.

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## *Gasoline Economy—Model "A" Ford**

*The following is a brief summary of some work which was done in an attempt to arrive at a more economical combination of jets than those supplied as standard equipment for the carburetor on the Model "A" Ford.*

IN THIS instance it is intended that the Ford be governed at about 40 miles per hour, although a governor was not used in the test.

The work is not complete but shows something of relative economies which can be expected at different road speeds with different jet combinations. Further tests will be made in the future along similar lines.

The tests were run on a chassis dynamometer, which consisted of a modified Prony brake driven by the rear wheels of the vehicle. An orifice flow meter was used to record the rate of gasoline flow.

A Model "A" Ford coupe, which had been driven about 9,000 miles, with rear end ratio 3.69 was used. The various mechanical conditions, such as valve clearance, spark plug gap, timing, etc., were checked and kept at what is considered to be good practice, throughout the runs.

Runs were taken at various speeds up to 45 miles per hour on a level road and throttle settings marked. Runs at corresponding speeds were then taken on the dynamometer with corresponding throttle settings, and the power and rate of gasoline consumption noted. This power shown on the dynamometer would then be the amount necessary to drive the vehicle at the given speeds on a level road. The dynamometer gives very little indication of performance in acceleration. Combinations of jets should be checked on the road for performance.

Runs with various combinations of jets, gas savers, etc., were taken at the specified speeds, with the specified amount of power developed, and the rate of gasoline consumption noted.

### Results of Tests

Curves in Fig. 1 show the combination of jets which is the Ford standard, and two other combinations which were picked from those tried. Neither of these is considered as an ideal setting. However, the combination of main 17, cap 18, comp 19, would undoubtedly give much better economy than the standard Ford setting with very little, if any, loss of power.

If the left end of curve No. 11 were a little higher and the right end a little lower, it would probably be ideal for operation under 40 miles per hour. The combination of 18 main, 17 cap, and 19 or 20 comp should do this.

It will be noted from the curves that opening the dash adjustment affects the gasoline consumption at all speeds up to 40 miles per hour. It must be clearly understood that it is possible to use different rates of fuel for the same power developed and consequently for the same road speed. The flow of gasoline at speeds below 25 miles per hour is uneven, and probably accounts for the rather low economy at these speeds. It was necessary to damp the flow meter and read the average rate of flow. It will be noted that above 25 miles per hour, when the flow becomes steady, the economy

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* Written by C. R. Stanley for the technical division of the Transportation Section.

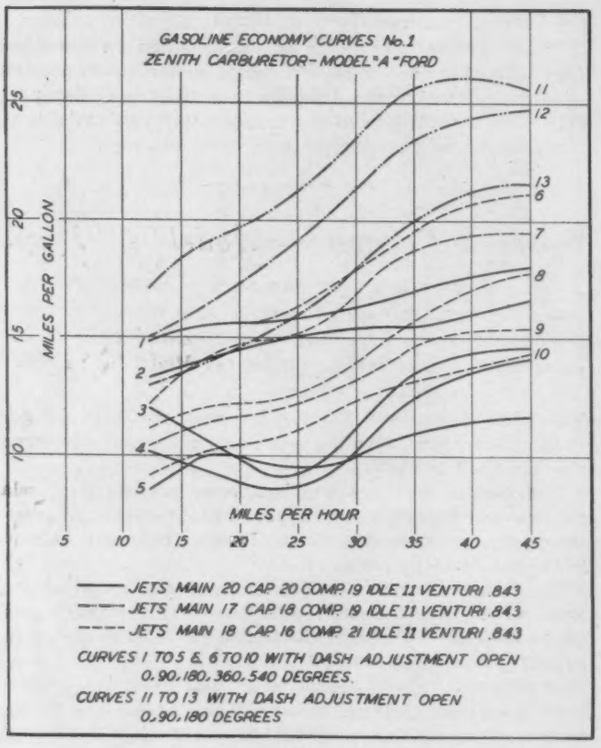
GASOLINE ECONOMY CURVES No.1
ZENITH CARBURETOR-MODEL "A" FORD
MILES PER GALLON
MILES PER HOUR
JETS MAIN 20 CAP 20 COMP 19 IDLE 11 VENTURI .843
JETS MAIN 17 CAP 18 COMP 19 IDLE 11 VENTURI .843
JETS MAIN 18 CAP 16 COMP 21 IDLE 11 VENTURI .843
CURVES 1 TO 5 & 6 TO 10 WITH DASH ADJUSTMENT OPEN 0, 90, 180, 360, 540 DEGREES.
CURVES 11 TO 13 WITH DASH ADJUSTMENT OPEN 0, 90, 180 DEGREES

*Fig. 1. Standard Ford combination of jets and two other combinations.*

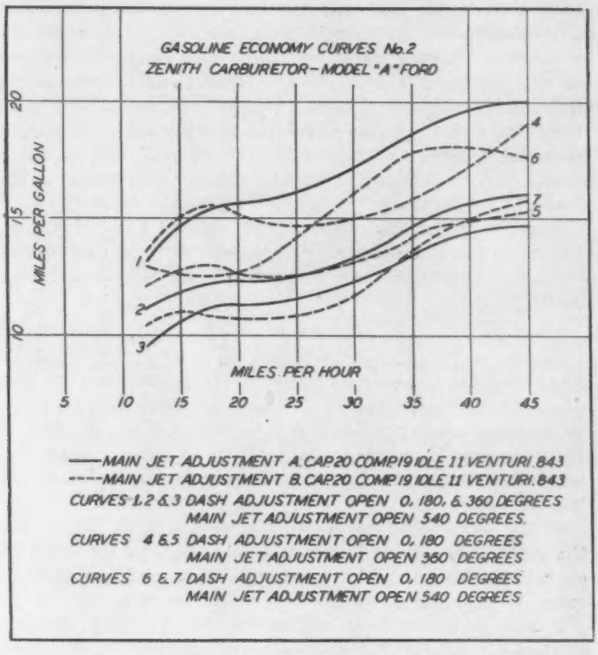
GASOLINE ECONOMY CURVES No.2
ZENITH CARBURETOR-MODEL "A" FORD
MILES PER GALLON
MILES PER HOUR
MAIN JET ADJUSTMENT A. CAP 20 COMP 19 IDLE 11 VENTURI .843
MAIN JET ADJUSTMENT B. CAP 20 COMP 19 IDLE 11 VENTURI .843
CURVES 1, 2 & 3 DASH ADJUSTMENT OPEN 0, 180, & 360 DEGREES MAIN JET ADJUSTMENT OPEN 540 DEGREES.
CURVES 4 & 5 DASH ADJUSTMENT OPEN 0, 180 DEGREES MAIN JET ADJUSTMENT OPEN 360 DEGREES
CURVES 6 & 7 DASH ADJUSTMENT OPEN 0, 180 DEGREES MAIN JET ADJUSTMENT OPEN 540 DEGREES

*Fig. 2. Two types of needle valve adjustments.*

goes up. This uneven flow was thought to be due to faulty float construction, and to test this, air was moved through the carbureter by a steady suction at a rate equal to that which the engine would cause for the given speeds. The rate of gasoline flow under these conditions was less, and remained steady. The pulsation from the cylinders was then assumed to be responsible for the uneven flow.

Curves in Fig. 2 show two types of needle adjustments. They have an effect similar to that of making the main jet smaller. The flow of gasoline when using them was more uneven at low speeds than with the standard jet. The curves on one seem to be a little erratic.

A special type of venturi flow meter has been developed for use on a motor vehicle on road tests. This, in conjunction with some type of accelerometer, should give information in regard to road performance in acceleration.

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# *Tires**

***The tire situation is rapidly changing and today tire repairs and replacements represent about 14 per cent of the operating cost of all automobiles and an even higher percentage of the cost of operating a truck. The following report is a discussion of some of the problems which must be met in selecting and servicing tires.***

THE introduction of pneumatic tires for large trucks made transportation for long hauls an economical operation. Up to that time, the solid or cushion tire was used and is still in use today on trailers and trucks for short hauls with extremely heavy loads, but for transporting materials over routes covering long distances to districts which are located far apart, the time element alone makes operating on solid tires prohibitive.

### Solid Truck Tires vs. Pneumatic High Pressure Tires

The pneumatic high pressure tire was a great improvement over the solid tire for the following reasons:

The pneumatic tire allowed a greater speed over the highways, a reduction in maintenance costs, an increase in tire mileage which decreased the tire cost per mile, and what was a most important feature, the increase of safety. One other great advantage was the flexibility of the trucks so equipped; the pneumatic tire permits a truck to travel on the boulevard, over rough mountain roads and into the sandy byroads and trails with a greater assurance of not getting stuck or delayed on account of road conditions. It is possible to substitute pneumatic for solid tires; there are a number of appliances on the market permitting the changing from solid or cushion tires to pneumatic or single pneumatics, or to dual pneumatics, which have proved very successful.

The pneumatic high pressure tire has many advantages. It has it disadvantages, too, some of which are: The overheating of the tire on long hauls where speed is required, the breaking down of sidewalls due to fighting the rough or washboard roads, and the greatest drawback of all, which is the fault of the operator rather than of the tire, its inability to carry the load without air. At the present time there is considerable controversy with reference to the use of pneumatic tires on trucks equipped with a winch device for setting poles, etc. Its unadaptability for such use would rank as another drawback for pneumatic tires.

The removal from the highways of the big trucks operating on solid tires has had a great effect in reducing the maintenance and operating costs of pneumatic tired vehicles. Aside from the many, many miles of new concrete highways which have been built within the past few years, the old macadamized roads are subjected to less abuse from the pneumatic tire and therefore are in a better condition to travel over.

### Balloon Tires

The balloon tire for passenger cars has proved its place as superior to the high pressure tire. Records show that the balloon tire for passenger cars has cut down tire costs, reduced the maintenance costs, increased safety and comfort. The next step towards tire improvements was the possibility

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* Report of committee on tires, technical division, Transportation Section. C. O. Hutchins, chairman.

of a low pressure tire for trucks and buses. The first development in this direction was a tire designed to fit a 24-in. rim with a carrying capacity of 2,400 lb. and an air pressure of 50 lb. This tire, with a carrying capacity equal to that of the 36 x 6-in. tire, but inflated to 40 lb. less air pressure, was found to permit greater speed and generate less heat under like conditions than a high pressure tire. Later on the balloon truck or bus tire was designed for a 20-in. and 22-in. rim.

### High Pressure Tires vs. Balloon Truck or Bus Tires

The balloon truck or bus tire permits higher vehicle speed and greater comfort, increases braking power and acceleration by providing additional traction, decreases deterioration of vehicle and road through greater cushioning, dissipates heat more rapidly, is less liable to bruise, due to increased cushioning and lower air pressure, and decreases tread wear, due to greater contact with the road, thereby decreasing pressure per square inch. A comparison of the area of contact between the tread of the tire and the road surfaces favors the balloon of comparable carrying capacity to the high pressure tire. It is obvious that the greater tread contact area of the balloon tire provides greater traction, thus increasing braking power and permitting greater acceleration, and further, this greater tread area decreases the danger of skidding, thus providing additional safety. With the greater tread contact areas, the intensity of pressure per square inch is much smaller than on the high pressure tire. This should reduce the natural abrasion of the tread area and therefore should deliver more miles per unit of tread depth than the high pressure tire.

### Changing From High Pressure Tires to Balloon

The carrying capacity for each size must be carefully studied, as this determines the proper size to be used. Rim and spacing data should be obtained in order to determine whether a given balloon size necessary to carry the load can be applied to existing high pressure wheel equipment without changing spacing or wheels.

Great care should be exercised in the matter of dual tire spacing, allowing sufficient clearance between the duals to take care of the increase in cross-sectional width of the tire (flexing) which comes with peak loads, irregular and high crowned roads.

In the case of a change over to 9.75 x 20-in. tires the engine will run 2.4 per cent slower than normal and speedometer will read 2.4 per cent lower than road speed.

Assuming that the engine turns over 1,700 r.p.m. on a truck equipped with 86 x 8-in. tires, at 35 miles an hour, then when 9.75 tires are put on this truck, the engine will turn over 2.4 per cent revolutions per minute less or approximately 40 r.p.m. less to obtain the same speed.

Particular attention must be paid to the selection of a valve of correct size and angle in order to insure proper seating of the valve between the tire beads. Clearance between the rim and the brake drum must be given consideration. It is of utmost importance that the valve be installed so as to facilitate checking air pressure of the rear inside tires just as easily as the front tires. Improper valve seating causes valve chafing and valve pad separation.

The use of puncture proof tubes or air containers has proved very successful for certain classes of work, as they not only retain the uniform air pressure required by balloon tires, but also give additional support to the side walls. The saving in initial cost of the balloon tire or bus tire over the high pressure tire is often sufficient to cover the cost of puncture-proof tubes or air container installation.

Every organization has its own method of upkeep for tires, but the one item which should be uniform, as there is but one solution to obtain the maximum from a balloon tire, is the regular checking of the air in tires. Regardless of the recommended air inflation there should be sufficient air in a tire to carry the load which it is subjected to, leaving the tire free to perform its duty without additional stress on the side walls. Further, it is quite essential that each tire on a vehicle be inflated equally at all times. This prevents uneven tread wear and does away with the shimmy effect in a vehicle which often is caused by one front tire being underinflated.

The following is an example of a permissible tire size with rims and spacings:

**TABLE I**

| Tire Size | | Wheel | Plies | | Rim Size | | Minimum Space | | Air Pressure | | Carrying Capacity | | Area Contact Square Inch | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H.P. | Balloon | Size | H.P. | Bal. | H.P. | Bal. | H.P. | Bal. | H.P. | Bal. | H.P. | Bal. | H.P. | Bal. |
| 36x8 | 9.75x20 | 20 | 12 | 12 | 8 | 8 | 11½ | 11½ | 110 | 70 | 3600 | 4200 | 27.00 | 37.50 |
| 36x8 | 9.00x20 | 20 | 12 | 10 | 8 | 7 | 11½ | 11½ | 110 | 65 | 3600 | 3500 | 27.00 | 34.42 |
| 34x7 | 8.25x20 | 20 | 10 | 8 | 7 | 7 | 10 | 10 | 100 | 60 | 2800 | 2800 | 20.95 | 30.20 |

# Constructive Committee Work in the Northwest Association

*By* M. L. HIBBARD

President, Northwest Electric Light and Power Association

WORD has gone out that the Northwest Electric Light and Power Association will not hold a general convention this year. While from some quarters this decision of the association executive committee will be regretted, I feel sure all members and others interested will recognize the wisdom of it in the circumstances. The action was in line with a policy of curtailment necessarily adopted by all the companies. Here was one rather large item of expense for each company concerned, and for the manufacturing and jobbing companies who customarily send delegates to the convention, that could be saved without affecting the wage and employment situation in the slightest. We will, of course, not permit the lack of a convention this year to impair the usefulness of our association work in the future.

*M. L. Hibbard*

As I review the worthwhile results achieved by the various sections during the past association year, as evidenced by the many excellent reports produced by committees, I am greatly impressed with the amount of energy and constructive effort that has been put into the work. I want to take this opportunity to congratulate the section chairmen, their committee chairmen, and committee workers on the studies they have undertaken and on the portrayal of these studies through their published reports.

The Accounting, Commercial and Engineering Sections have each held their customary midyear meetings with good attendance and the usual enthusiasm prevailing. The subjects reported upon and discussed at the Accounting and Commercial Section meetings are disclosed in the reports published in the following pages. The Engineering Section will publish its reports in another form and I understand these will be available shortly. The Public Relations Section is to hold its meeting later on in the year, and will again feature the finals in the association public speaking contest.

Space will not permit here a resume of the work of the association during the past year, but by way of arousing interest in this work I would like to call attention to a few high spots.

The use of machines in various accounting procedures occupied much of the attention of the Accounting Section, as did also many phases of merchandise accounting. Each bureau of the Commercial Section had valuable suggestions to offer for ways to develop our business, while the report of the general merchandising committee presented an excellent analysis of the reasons for utility merchandising activities and the benefits to the public and to other electrical dealers resulting therefrom. Another very interesting analysis was by the promotional rates committee, showing the effect of our rates on our residential business. In the Engineering Section, perhaps the most far-reaching work was the research on causes of radio interference from pin type insulators being conducted at Oregon State College, progress on which was reported at the section meeting in March. A number of other valuable studies in all fields of construction and operation were also presented at that meeting, among which might be mentioned the forecasting of rainfall and climatic cycles from a study of tree rings.

These and many other subjects of varied interest and worth are treated in the reports printed in the following pages and to be printed in the Engineering Section publication. I would urge every person in the utility industry in this territory to examine these reports, since everyone is sure to find therein an analysis or discussion of some problem bearing directly on his particular work.

# Accounting Section Reports*

## *Introductory Statement*

By R. H. JONES, Chairman

THE Accounting Section this year adopted the general policy of rotating its midyear conference around the territory, and commenced the operation of this policy by holding the 1931 meeting at Salt Lake City on April 13 and 14. An excellent program was provided by committee chairmen, all of whom were able to give a good account of the work of their committees.

A resume of the discussions at this meeting will appear in the June 1 issue of *Electrical West*. The papers and reports presented and discussed at the meeting, except the report of the research committee, which does not receive general distribution, are published in the following pages.

* Executive Committee: R. H. Jones, chairman; W. F. Miller, vice-chairman; M. J. Wilkinson, F. W. Brownell, R. W. Miller, C. F. Kirchhaine, L. E. Hinman, B. H. Parkinson, O. W. Bennett, E. W. Moreland, B. Gadeholt.

## CUSTOMERS' RECORDS[1]

DURING the year just passed, the customers' records committee gave its attention to a study of service contracts, methods of handling merchandise installment accounts, a system of merchandise accounting using the Hollerith machine, and collection and credit methods with particular reference to merchandise installment accounts.

The results of these studies are embodied in the following five papers.

### *Investigation of Service Contracts for Retail Customers**

By R. W. LAWLOR

THE customers' records committee on the investigation of service contracts for retail customers, has carefully considered the things which go to make up a good service contract, and feels that more liberal provisions may be specified in a service contract for residential customers than those specified in a service contract for commercial and industrial customers. The committee has therefore divided this subject into two classes, namely:

1. Service contracts for residential customers.
2. Service contracts for commercial and industrial customers.

Your committee realizes that the creating of favorable public relations is extremely important and that much is continually being done by the utilities to further good will by carefully considering the point of contact with customer. Your committee feels that the drawing of a service contract is a very important contact with the customer, and that by the elimination of any so-called "red tape" in the service contract, which may serve to inconvenience the customer, an important step has been made in the furthering of good will.

In considering the requirements necessary for a residential service contract, we realize that a contract may be made extremely strong and legally binding on the customer by requiring his signature for each class of service obtained and for every time he changes his location of service, and by stipulating a specific term for contract, but we have also taken into consideration the fact that only in a comparatively few cases does the utility elect to start suit for the collection of a residential account, regardless of how legally binding the contract may be.

After carefully considering both the importance of our contractual relations with customers in establishing good will, as well as the necessity for reasonable and proper protection for the company, we believe that a simplified form of service contract for residential customers can be adopted which will accomplish:

(1) A better feeling and additional good will among customers by saving them time and inconvenience.

(2) A saving in time and expense through clerical work in the customer's office.

(3) A simplified record by combining the application for service with customer's index.

#### Service Contracts For Residential Customers

*1.—Convenience to Customers—*

A 4x6 card is recommended, on the face of which is printed the application for service, which provides for any and all service which the customer may take from the company from time to time at any and all location or locations in any district served by the company's plants or lines, and this application is signed by the customer. After the customer has signed the application, he may in the future apply for additional classes of service, or may move from one address to another, without the necessity of signing another application. In most cases, when the residential customer has first signed the application, a deposit has been obtained sufficient to guarantee payment of the final bill, and the customer also understands that, if current bills are not paid within the due date, service will be discontinued.

In towns where ruinous competition exists, it may be necessary to adopt a stricter and more binding form of contract, but where ordinary competition exists, the cases are comparatively few where the utility elects to sue for the breaking of contract when customers change and take service from a competitor. In most cases the first signing of the contract has the same effect on the customer as if the contract were airtight, with no legal loophole left for evasion. We believe that the company derives little benefit from requiring the customer to again sign the application when change of address is made or additional service is required, but we do believe that by saving him the time and inconvenience of either coming into the office

[1] Report of the customers' records committee, Accounting Section. C. F. Kirchhaine, Puget Sound Power & Light Company, chairman.
Pacific Power & Light Company: R. N. Lawlor, F. L. Nagel.
Puget Sound Power & Light Company: E. P. Donegan, Claude Marshall, A. R. Weidemann.
Utah Power & Light Company: Gus Anderson.

* A report of the customers' records committee, Accounting Section.

to sign or having to sign at his home, a more friendly feeling has been created between the customer and the company, which will more than offset the small losses occasioned by this more liberal policy.

*2.—Saving in Time and Expense—*

A saving in clerical time is made by not having to abstract the application from the file to obtain additional signature for each additional schedule obtained and for each time customer changes his address, and then to refile the application again, and a saving is made in not having to send the application to the customer's home for signature when he does not call at the company office.

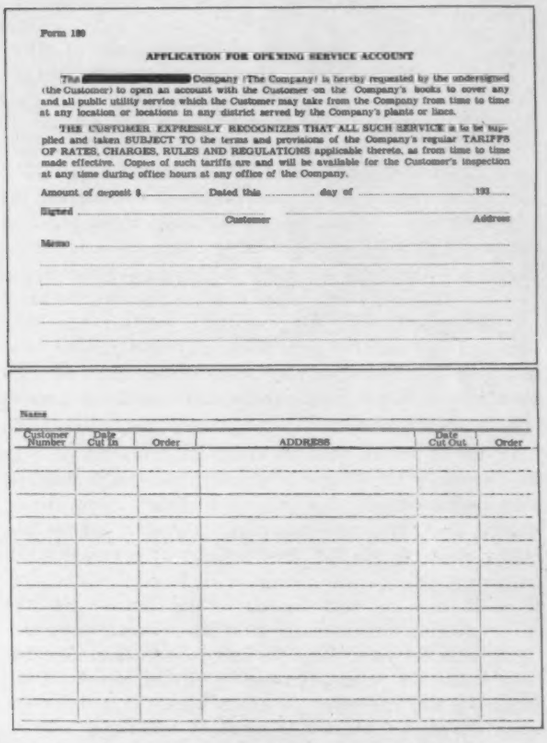
*3.—Simplified Record—Application For Service Combined With Customer's Index—*

The face of the application card contains the contract and the customer's signature and also information relative to the customer's previous address, and the condition of his account when service is finally discontinued. On the back of the application card is the customer's index, containing the customer's name, account number, date service was cut in, address, date cut out, and order number, with space for twelve changes of address. This combines on one card the application for service, containing customer's signature, and the customer's index card, and is filed alphabetically, making a complete and simplified record which can be used for credit reference, if desired.

## Service Contracts For Commercial and Industrial Customers

On account of the nature of demands and classes of service taken by commercial and industrial customers, we feel that a more binding contract is necessary than that required from residential customers. The service application and contract recommended for commercial and industrial customers is a 4x6 card, on the face of which is printed the contract with the company, and which must be signed by the customer, and each commercial or industrial customer is required to sign a new contract when change of address occurs. When additional service is required at the same address, space is provided on the same contract for recording additional schedules, and the customer's signature is required opposite each schedule for service. On the back of the service application and contract card, space is provided for the customer's name, address, account number, order number and date for schedules connected and disconnected, information pertaining to the final bill, amount of deposit, and balance due when account is finally closed, thereby leaving an alphabetical record in detail which is referred to should customer again apply for service.

The accompanying forms show the face and back of the "Application for Service Account" for residential customers, and the "Service Application and Contract" for commercial and industrial customers.



Form 180

APPLICATION FOR OPENING SERVICE ACCOUNT

The [redacted] Company (The Company) is hereby requested by the undersigned (the Customer) to open an account with the Customer on the Company's books to cover any and all public utility service which the Customer may take from the Company from time to time at any location or locations in any district served by the Company's plants or lines.

THE CUSTOMER EXPRESSLY RECOGNIZES THAT ALL SUCH SERVICE is to be supplied and taken SUBJECT TO the terms and provisions of the Company's regular TARIFFS OF RATES, CHARGES, RULES AND REGULATIONS applicable thereto, as from time to time made effective. Copies of such tariffs are and will be available for the Customer's inspection at any time during office hours at any office of the Company.

Amount of deposit $ ..... Dated this ..... day of ..... 193....

Signed ..... Customer ..... Address

Memo .....

Name .....

| Customer Number | Date Cut In | Order | ADDRESS | Date Cut Out | Order |
|---|---|---|---|---|---|
| | | | | | |
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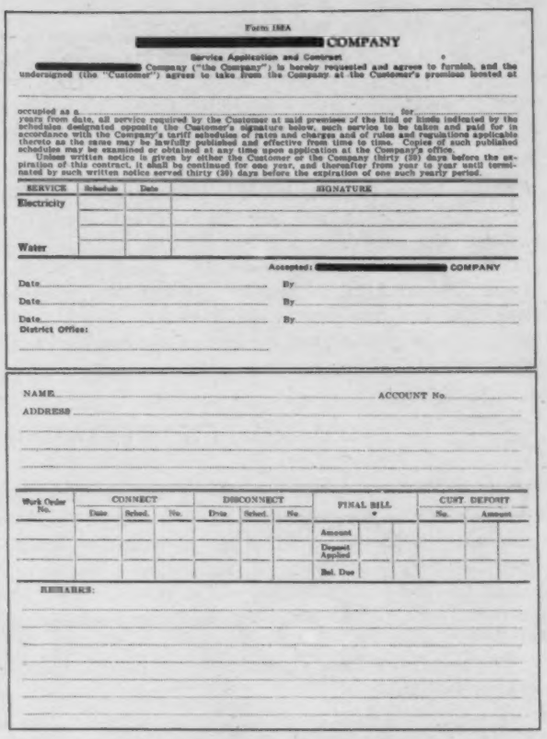
*Fig. 1. Sample of service contract for residential customers, with customer's index on back.*



Form 180A

[redacted] COMPANY

Service Application and Contract

[redacted] Company ("the Company") is hereby requested and agrees to furnish, and the undersigned (the "Customer") agrees to take from the Company at the Customer's premises located at .....

occupied as a ..... for .....

years from date, all service required by the Customer at said premises of the kind or kinds indicated by the schedules designated opposite the Customer's signature below, such service to be taken and paid for in accordance with the Company's tariff schedules of rates and charges and of rules and regulations applicable thereto as the same may be lawfully published and effective from time to time. Copies of such published schedules may be examined or obtained at any time upon application at the Company's office.

Unless written notice is given by either the Customer or the Company thirty (30) days before the expiration of this contract, it shall be continued for one year, and thereafter from year to year until terminated by such written notice served thirty (30) days before the expiration of one such yearly period.

| SERVICE | Schedule | Date | SIGNATURE |
|---|---|---|---|
| Electricity | | | |
| | | | |
| | | | |
| Water | | | |

Accepted: [redacted] COMPANY

Date ..... By .....

Date ..... By .....

Date ..... By .....

District Offices: .....

NAME ..... ACCOUNT No. .....

ADDRESS .....

| Work Order No. | CONNECT | | | DISCONNECT | | | FINAL BILL | | | CUST. DEPOSIT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | Sched. | No. | Date | Sched. | No. | | | | No. | Amount |
| | | | | | | | Amount | | | | |
| | | | | | | | Deposit Applied | | | | |
| | | | | | | | Bal. Due | | | | |

REMARKS: .....

*Fig. 2. Service contract as used for commercial customers with customer's index on back.*

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# *Methods of Handling Merchandise Installment Accounts**

By GUS ANDERSON

AN investigation of the handling of merchandise installment accounts revealed the following methods which have proven practical, and are in use by different utility companies where energy accounts and merchandise installments are shown on one bill rendered to the customer.

All the machines mentioned in this article automat-

* A report of the customers' records committee, Accounting Section.

ically accumulate totals by districts or ledgers and by the day, as the charges are posted to the merchandise accounts, and are handled in conjunction with the service accounts. The first two are under the register sheet plan, and the others under the individual account card system.

The Remington Company suggests that as soon as a contract is received, a confirmation be made up and sent to the customer. This allows a speedy adjustment of any misunderstanding which might have occurred between a representative of the company and the customer. The confirmation shows the date, name of salesman, order number, description of article purchased, amount of purchase, amount of credit to be given on old appliance, net amount, the initial payment and the amount of the monthly installment, as well as the name and address of customer. As this is written, a commission record, a storeroom record and a customer's ledger sheet are prepared. The commission record is filed in the office; the storeroom record is sent to the storeroom, where it is held until the merchandise has been delivered or installed, when it is returned to the office and matched up with the commission record, from which the salesman's commission statement is prepared. The ledger sheet shows a complete copy of the confirmation sent to the customer. Monthly payments, as they are received, are posted to this ledger sheet and the unpaid balance extended. This system provides for the merchandise contract accounts being carried in an auxiliary container separate from the service accounts. The sheets are arranged in district and folio order and a separate control is carried on the accounts for each district. This makes it possible to balance a district the same day as the corresponding electric accounts are balanced, and allows a proof of accounts before the monthly installments are brought forward on the electric bills.

The Hollerith punching system, sold by the Tabulating Machine Company, provides for the punching of the number of cards necessary to complete the contract, using one card for each installment. One of these cards is included with the regular billing cards each month and shown on the bill as a merchandise item, or in case of a merchandise balance being brought forward, both merchandise and merchandise balance are shown. These cards are filed by route and due dates, and the cards for a route to be billed are sorted out by dates and combined with the regular billing cards. This operation is repeated each month until such time as the account is cleared.

The Underwood Typewriter Company, in connection with the use of the Underwood Bookkeeping Machine, recommends a separate ledger sheet for the contract merchandise to be filed in the same container with the other ledger sheets, just behind the regular consumer's service account. All contract merchandise is entered on these ledger sheets, together with the initial payment on same. As the deferred payments come due, they are transferrd to the current bill and ledger sheet and the deferred balance on the merchandise sheet is reduced accordingly. Thus, the total current account is always reflected on the regular ledger sheet and all cash payments are posted thereto with the exception of the initial payment.

Under the Burroughs plan, the ledger card for the contract metrchandise is filed in the service ledger, together with the regular service accounts. When the bills for energy are being prepared, the installment is obtained directly from the merchandise account card and entered on the customer's bill. It is recommended that the contract accounts be divided into months to correspond with the service accounts. This provides the same advantages that would be secured were the payments set up in advance and these checked off as paid. An entry is made in each month's section, either in the credit column or the arrears column.

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## *Hollerith System of Merchandise Accounting**

By C. F. KIRCHHAINE

THIS paper is the result of a study made to simplify merchandise and jobbing accounting in the stores, sales and accounting departments, and falls naturally into three classifications:

1. Merchandise stores accounting.
2. Forms used for recording sales and delivery of merchandise.
3. Billing of merchandise and jobbing charges.

Each classification will be discussed in the order named.

### 1. Merchandise Stores Accounting

*A. Purchasing of Merchandise—*

Storekeepers should be furnished with a copy of all purchase orders affecting merchandise supplies.

*B. Receiving of Merchandise—*

A receiving room should be established in each district merchandise storeroom and a ruling made that direct shipments should not be made from jobbers to sub-storerooms, this ruling to be broken in rare cases where it is necessary to rush material to a sub-stock, in which case these shipments are to be recorded as though received in the district storeroom and as though they were issued from the district storeroom to the sub-stock.

When merchandise is received in the main storeroom, a material receipt is made by the receiving clerk showing name of shipper, purchase order number, number of pieces in the shipment and the condition of the material received.

The material receipt number, together with the date and the number of pieces in the shipment, will be shown on each package. The receiving clerk will remove the storeroom copy of the purchase order from the file and attach the material receipt to it, together with the jobber's shipping order. The merchandise, together with the above papers, should then be turned over to the checking department.

*C. Checking of Merchandise—*

The employee responsible for the checking of all merchandise received will check the shipment against the purchase order, recording on same the material receipt number, date received, etc. In the event of a shortage or damaged goods, the purchasing department should be notified and the claim originated. After the shipment has been checked, both the merchandise and papers will be turned over to the marking department.

*D. Marking of Merchandise—*

Merchandise shipments are held in the marking room until invoice is received from the jobber. When invoice is received, the unit cost is computed and recorded on the storeroom copy of the purchase order.

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* A report of the customers' records committee, Accounting Section.

The invoice is then passed to the accounting department for payment. The purchase order is placed on file, awaiting the assignment of a retail price by the merchandise sales manager. A notice of arrival of goods will be prepared and forwarded to the merchandise sales manager, who will assign the retail price on each item, returning this notice with sales price so indicated to the district storeroom.

Each morning the merchandise sales manager should assign retail prices on all material which has been received and checked and for which invoice has been passed for payment the previous day.

After the retail price has been placed on the purchase order, the merchandise is ready for marking. It is proposed that two types of tags be used in marking merchandise, namely, a string tag and a sticker tag. Both tags should be approximately 1½ in. square. Tags will be printed and certain standard information will be shown on each tag. Each item of information should be shown in a standard location on the tag. It is suggested that the first line of the tag show the purchase order number. The second line on the tag should show the year and month in which the merchandise was purchased, somewhat as follows: "1-1," representing January, 1931; "11-0," representing November, 1930. This item of information should be recorded on all inventories taken and will be a valuable index to slow moving merchandise. On the same line of the tag will be shown a code number indicating the class of merchandise. This code number will be shown on all sales slips and will provide valuable statistical information. The third line will show the name of the article. The fourth line will show the serial number, if any. The fifth line of the tag will reflect the cost price of the merchandise in code. The sixth line of the tag will show the retail price of the merchandise.

On large appliances it will perhaps be feasible to use two tags, one sticker tag and one string tag. On merchandise received in cartons, it will be necessary to use two tags also, one on the outside of the carton and another on the appliance. After the tagging operation on any lot of merchandise is complete, a recheck should be made against the total cost price and total sales price shown on the storeroom copy of the purchase order. The merchandise is now ready for sale and should be sent direct to the sales floor or placed in the reserve stock.

*E. Storing of Merchandise—*

As material is received by the storekeeper from the marking room, it should be placed on shelves or in bins. The older material should be kept in the front of the bin and the new merchandise not used until the old lot is exhausted. This can be easily controlled through the season number which shows on all tags. As merchandise is requisitioned from the storeroom, the cost of the merchandise will be transferred from the tag to the requisition. As no stock cards will be maintained under this plan, maximum and minimum quantity information will be shown on all bin cards or on charts covering a certain section of shelving, or a drawer containing more than one item. This routing will apply on the smaller items of merchandise. The working supply of large appliances will be maintained through frequent check.

*F. Inventorying of Merchandise—*

The above plan will necessitate frequent inventories. Main stocks should be inventoried semi-annually and sub-stocks three or more times a year. Inventories will be compiled directly from the tags and the year and month of purchase should be shown opposite each item inventoried.

*G. Control of Merchandise on Hand in Sub-Stocks—*

It is suggested that monthly reports be made on all sub-stock, showing quantity on hand. This will tend to reduce over-stocking in suburban offices and will aid in the disposal of slow-moving items of merchandise.

*H. Returned Merchandise—*

Merchandise accepted in part payment on the purchase of other merchandise, or merchandise repossessed because of non-payment, should be sent direct to the receiving department and, from that point on, will be handled the same as the purchase of new merchandise, except that a return stock slip will be issued and used in lieu of an invoice for making price tags, etc. When merchandise is exchanged by the customer, the original tag will generally be on the returned merchandise. If not, the original sales slip can be referred to for cost information.

*I. Summary of Merchandise Stores Accounting—*

Although the receiving, checking and marking of merchandise have been set up as separate operations in the foregoing, it is very probable that two or more of these operations can be performed by the same employee. It is important, however, that the space used in performing these operations be completely separated from the storeroom proper by a partition of some kind.

Due to the elimination of the storeroom cards, it is very necessary that a strict rule be enforced in regard to the removal of merchandise from storeroom or sales floor without the making of the proper records. Removal of parts from any article of merchandise for repair purposes should be discouraged. Quite frequently the part removed is not ordered and the appliance is useless for sales purposes.

### 2. Forms Used for Recording Sales and Delivery of Merchandise

Sales of merchandise are divided roughly into three classes, namely:

1. Cash sales.
2. Open account sales.
3. Contract sales.

*1. Cash Sales—*

It is recommended that a cash sales register sheet and a two-part stub be used for recording cash sales, the cash sales on each sales floor to be accumulated on the register sheet and a two-part stub to be made for each individual sale, one part of which is passed to the customer, the other being retained by the cashier for balancing purposes.

The cash sale register sheet provides for description of the article sold, cost of same, the sale price, the code number classifying the item sold, the salesman's number and the serial number of the sale. This cash sale register sheet is closed each day when the cashier of the sales floor closes the sales collections. The total on the cash sales sheet, of course, balances with the cash sales amount recorded on the cashier's daily cash report.

The daily cash sales register sheet provides a summary for revenue and stock account classifications. At the close of business each month, the daily cash

sales sheets are summarized to stock account and revenue account entries. The daily cash sales register sheet also provides for the return of merchandise and shows reference to the original sales number. A two-part return stub should be made on which the customer will receipt for the cash received and which will be used by the cashier for obtaining refund through petty cash voucher.

*2. Open Account Sales—*

It is proposed to record open account sales on a three-copy charge sale which will be so designed that it will act as an installation and delivery order. The original of the charge sale slip is perforated to form a stub on the right-hand side. The original records the name and address of the customer, item sold, sales price, cost in code and classification number. The stub records the name and address of the customer and the amount of the sale. The duplicate records the same information as the original and additional space is provided for the extension of the stores cost and revenue classification. The triplicate records the same information as the original and is used only when a contract sale is made. It provides space for installation information and a space for customer's signature after the appliance is installed. The carbons used in writing the charge sales extend only as far as the stub on the original.

Ordinarily, the third copy is not used in recording open account sales. If the merchandise being purchased is not located in the sales floor stock or if the customer requests delivery, the third copy is used as a requisition by the service department on the storekeeper for the merchandise. If the customer takes the merchandise with him, the third copy is destroyed. The customer is given the stub of the original for identification purposes in the event of the return of the merchandise. The first and second copy is then sent direct to the accounting department for billing.

*3. Contract Sales—*

Contract charge sales slips are to be prepared from conditional sales agreements, which will be turned in each day by the salesmen. The charge sale slip is the same as that used for open account sales and all three copies are to be utilized. The charge sale slips are to be sent direct to the credit division for credit approval. The original is to be sent by the credit division to the accounting department, where it is held pending the receipt of the duplicate from the stores department. The duplicate is to be sent to the storekeeper, who retains it until the merchandise is requisitioned by the installation department. The triplicate is to be sent to the installation department. Upon receipt of the triplicate, the installation department uses it as a requisition on the storekeeper for the merchandise detailed on the sales slip.

The storekeeper matches it with the duplicate, fills in the cost information on the duplicate and turns the merchandise over to the installation department. The storekeeper then forwards the duplicate to the accounting department. The merchandise is delivered and installed by the installation department and the customer's signature is obtained in the space provided on the triplicate. The third copy is filed as a permanent record by the installation department and is used as a record for maintenance during the guarantee period, and as a basis for service charges after the guarantee period has expired.

3. Billing of Merchandise and Jobbing Charges

The above section of the plan will be discussed in two sections:

A. Accounting routine prior to the Hollerith operation.
B. Hollerith operation.

*Accounting Routine Prior to Hollerith Operation—*

It is planned to combine into one account merchandise charges and power and light charges. It is felt that collection of merchandise and jobbing charges will be facilitated if they appear on the light and power bill. The customer will receive only one bill a month, and collection information will be obtained from the combined record.

*Open Account Sales—*

On open account sales, the accounting department receives the original and duplicate copies of the charge sale slip. These are generally received at the same time unless delivery or installation is necessary on the merchandise sold. In any event, the accounting department takes no action on any sales slip until the duplicate copy of the charge sale slip is received, as the receipt of the duplicate copy serves as an indication that the sale is complete. The charge sale slip is referred to the customer index and the route and account number is placed thereon. The original and duplicate sales slips are then filed in route and account number order until the route to which they apply is read. After the meter reading is complete the duplicate charge sale slips are sent, together with the meter book, to the Hollerith division, where the merchandise is billed together with the light and power charges. When the completed bills are received from the Hollerith division, the original sales slip is attached to the bill and serves as supporting detail for the merchandise items shown on the bill. The duplicate sales slip is filed permanently in route and account number order. At the end of the month, the Hollerith division furnishes the accounting department with a summary sheet for merchandise charges billed and this summary is used as a basis for a journal entry debiting and crediting the various revenue and stock accounts.

There will be a certain number of open account sales each month which cannot be billed with the customer's light and power charges, due to the customer not having a service connection. It is suggested that such charges be assigned to a miscellaneous route and the charge sale slip number be used as the account number. These charges will be billed at the end of each month and the original of the charge sale slip mailed to the customer. It will be necessary to maintain a separate index file for this type of sales to provide for requests for duplicate bills and for collection purposes.

*Contract Sales—*

All contract sales will be charged to a separate account entitled "Unbilled Installments" from which the monthly installments will be journalized each month as the customer's meter is read. Down payments on contract sales will be credited to the customer's power and light account.

As contract charge sales slips are received by the accounting department, they are referred to the customer's index to obtain the customer's number, and posted to the unbilled installments ledger. A listing is prepared for the amount of the down payments which is used for journalizing debits to "Accounts Receivable Consumers" and credits to "Unbilled Installments."

These charge sales slips are forwarded monthly to the Hollerith division for summarizing the entries to the various stores, revenues and unbilled installments. The unbilled installments ledger is arranged in route and account number order, and as each route is read, a listing is prepared charging the customer's power

and light account and crediting the unbilled installments ledger. The listing shows the customer's name, item being purchased, amount of installment and route and account number. The original of the listing is sent with the meter reading book to the Hollerith division and the duplicate is retained by the accounting department as a basis for a journal entry at the end of the month, charging "Accounts Receivable Consumers" and crediting the account "Unbilled Installments." The duplicate is also used as a medium for posting the individual credits to the unbilled installments ledger. A short description is shown on the power and light bill opposite the amount of the installment.

As in the case of open account sales, there will be a few contract sales which cannot be assigned a route and account number. These sales should be placed under a miscellaneous route number and the charge sale slip will act as the account number. The installments on these miscellaneous contract sales will be billed at the end of each month.

*Final Bills—*

All service disconnect orders should be routed over the merchandise accounting clerk's desk in order that pending open account sales may be placed on the final bill. The original sales slip is attached to the disconnect order. The duplicate charge sale is stamped "Disconnected" and when the route is read, the merchandise charge is billed in memorandum only.

All service desconnect orders are also referred to the unbilled installments ledger and in the event that the customer discontinuing service has a contract account, the credit division should be immediately notified and arrangements made with the customer for the payment of future installments. Of course, if the customer is moving to another point which is within the jurisdiction of the district office, the contract ledger sheet can be moved to the new route location.

*Numbered Records—*

It is considered very necessary that a record of serial numbers of sales slips be maintained to insure the billing of all items.

*Cash Payments—*

As stated previously, amounts equal to the down payments will have been journalized from "Unbilled Installments" to "Accounts Receivable Consumers," likewise any payment in excess of the monthly installment should be the subject of an adjustment transferring a like debit from "Unbilled Installments" to "Accounts Receivable Consumers."

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# *Investigation of Collection and Credit Methods for Merchandise Installment Accounts**

By A. R. WEIDEMANN

PRIOR to the national retail credit survey, conducted by the U.S. Department of Commerce on request of the National Retail Credit Association, very little definite information was available as to the ratio of installment credit to open account credit and cash sales, collection percentages and losses in a nation wide comparison. This survey of the 1927 sales and a later semi-annual survey on a smaller scale furnish the retail merchants with some very interesting facts for their guidance, and these data have been to a great extent a determining factor in preparing this paper.

### Credits

The importance of installment sales of electrical appliances is indicated by the 1927 survey as follows: 49.2 per cent installment credit, 35.4 per cent open credit, 15.4 per cent cash. The constant increase of installment sales is shown with a percentage of 54.5 for 1929 and 55.8 for the first six months of 1930. The installment business, therefore, is more than the combined sales on open accounts and for cash.

The credit losses on electrical appliance sales in 1927 were 1.5 per cent for installment credits and 1.5 per cent for open credits, but in 1930 the figures have been changed to 0.8 per cent and 2.2 per cent respectively. This would indicate a tightening of credit granting and terms on installment sales and a slackening grip on open accounts. In comparison, the 1930 survey shows that all lines of business within its scope had an average loss of 1.9 per cent for installment credits and 0.6 per cent for open credits. A detail study of credit losses on installment sales of electrical appliances discloses a great fluctuation in percentages, from an insignificant figure to losses of 5 per cent or more.

The general consensus of opinion now grants that credit approval is essential on open account sales, but we frequently find the impression that installment selling needs very little attention by the credit department, due to the preferred claim obtained by the use of conditional sales agreements and the right to repossess. In fact, some credit men have become indifferent as to establishing the credit rating of the contract customer. This thought or feeling of security probably would not result in serious losses if the sales were based on established terms, that are protective as to risk, and were it feasible to execute and record all contracts in strict accordance with the existing laws to maintain the preferred lien. In practice, however, this theory apparently has failed and has proved disappointing and expensive.

Why should we be faced with undesirable losses when we apparently have the best of legal and physical security? The answer is really quite simple, as there is no real problem. The firms that take the heavy losses and are instrumental in establishing a high average of bad debt, voluntarily prefer to accept this condition as commercial losses within reason, in order to increase an apparent sales turn-over.

Merchandising of appliances by the public utility companies is primarily a method of inducing new and additional consumption of their main product, electric current, and for that reason the sales terms frequently are made extremely easy and apparently without regard for established safety principles.

*Principles of Installment Selling—*

Outstanding men in financial and credit circles agree on certain safety principles in determining installment terms, as follows:

1. Down payment should be:
   (*A*) Sufficient to approximate the initial depreciation or the difference between the first and second-hand values,

* A report of the customers' records committee, Accounting Section.

as the unpaid balance should not be greater than the value of the article.

(*B*) Sufficient to create in the buyer a sense of ownership and to eliminate a desire to return the article on account of the financial loss in case of default.

(*C*) Sufficient to cover the dealer's profit or anticipated price reduction.

2. Periodical payments should not extend beyond the commercial life of the merchandise or be less than the progressive depreciation.

Through experience and statistics we have learned that credit losses increase in ratio with:

(1) Decrease of down payment below initial depreciation.

(2) Lengthening of contract life beyond repossession values.

We find that losses on installment sales will exceed losses on open account sales when we disregard or depart from the well defined principles of sound and recognized rules of financing and credit granting. If sales and credit policies were entirely based on terms as previously mentioned, it is safe to predict that the average percentage of losses would be materially reduced, but most concerns have a much more liberal policy as to terms, chiefly due to competition and intensive merchandise campaigns for sales.

*Credit Control Necessary—*

It is generally thought, of course, that the repossession right, regardless of credit rating, is sufficient protection and that the increased load revenue compensates for the installation and repossession expense and depreciation. This thought apparently is dangerous and frequently leads to heavy losses, as the slow and undesirable account is expensive to collect and to encourage increased consumption from this source would probably result in discontinuance of service in addition to repossession of merchandise.

Small appliance contracts, amounting to less that $25.00, are seldom recorded on account of the expense and, therefore, do not constitute a preferred claim in most states and are in fact equivalent to an open account, except for their moral and legal value as a written agreement. A considerable loss is experienced by all firms on small appliance sales on account of "skips," that is, the customer disappears and takes the appliance with him. There is only one remedy or protection available to reduce such losses, viz., proper credit granting.

Even under the most stringent terms and rules, we acknowledge the necessity of some credit supervision, but when the down payment goes down to 3 per cent or is entirely eliminated and the contract runs over a period of two years and sometimes more, efficient credit granting becomes essential to offset the additional risk.

In order that we may better understand the practical value of conditional sales agreements, it is well to investigate the thought that enacted and placed the supporting laws on the statutes. It is doubtful if our lawmakers intended to support or place in the hands of the merchants a foolproof instrument to protect them only and not the buyer, regardless of terms, credit rating and execution of contract. It is unreasonable to believe that they desired to encourage promiscuous selling and to relieve merchants entirely of all responsibility as to credit risk. We probably will arrive at more healthy conclusions if we assume that protection was offered to legitimate sales, where there is no apparent reason for inability to meet the obligation. We are, it is thought, in the same position as the material men with the mechanics lien law. Through repeated court decisions, detrimental under certain conditions to their priority lien, they are gradually recognizing the fact that credit rating is their first line of defense against losses and that the law is a secondary line of defense, to protect the seller against losses due to unforeseen and uncontrollable circumstances.

In addition to the direct financial loss, consideration should be given to one of the most important assets of any commercial house, viz., public relations and good will. It is certain that promiscuous selling, based on repossession rights only, will soon damage a firm's reputation of fairness and reliability in a community, and that it removes two of the most essential advertising and sales features. We cannot as a rule directly improve the financial rating of our customers to make sales, but it is within our authority and right to prevent sales that cause financial loss as well as good will. There seems to be only one logical answer: Perfect credit control is required on installment sales as on open account sales.

The present day credit desk, if it is given sufficient authority and is competently handled, has the required facilities to determine without delay the credit status of practically all accounts within its district. The credit department's information file is rapidly built up from accounts receivable, trade and credit bureau reports and newspapers. New accounts are promptly covered through affiliation with local and national credit associations, as the network of credit information now covers most of the globe and is available to all business houses.

The most essential point of credit control, of course, consists of such regulations as will allow the credit man or his agents to approve or reject a prospective sale before it is consummated or merchandise is delivered.

In our aggressive endeavor to promote and induce sales it is not unusual to deliver merchandise to customers on trial or subject to approval. Requisitions for such articles should be approved for credit rating before delivery, to eliminate unnecessary expense and depreciation in event of undesirable accounts.

## Collections

Collection percentage used in the retail surveys is the ratio of the monthly collections on accounts receivable to the outstanding balance when closing the books for the previous month. In the 1927 national survey we find an average percentage for all lines of business as follows: 44.1 per cent on open accounts and 13.5 per cent on installment sales. For electrical appliances, we have 39.2 per cent and 16.0 per cent respectively, indicating that open account collections were under the average for all lines and installment collections were over the average.

However, in the semi-annual survey for 1930 we find the result changed, as the average for all lines was 42.6 per cent on open sales and 15.3 per cent on installment sales, with electrical appliances having averages of 50.4 per cent and 13.6 per cent respectively. Practically all other lines increased their installment collection percentages considerably, but the electrical appliances decreased the average 2.4 per cent.

Previously we have shown that credit losses on electrical appliance installment sales decreased materially in the 1930 survey compared with the 1927 survey, and now the statistics disclose that the collection percentage has also decreased. Why should we have such conflicting figures, when it is natural to assume that decreased credit losses are the result of increased collection percentages? It is possible that a number of the firms included in the survey for the first six months of 1930 do not budget their credit losses by the month,

and that these losses are charged off toward the end of the year, which, of course, would account for the reduction of bad debt losses indicated.

We do not believe that this is the influencing factor, however, and are more inclined to the theory that a better credit control has eliminated many "skips" and undesirable accounts and that a more lenient collection policy has been applied to the accounts that are temporarily unable to pay according to terms, or that the average contract life has been lengthened.

We know from experience that credit losses will increase in ratio with increases of delinquencies, but it is thought that a reasonable leniency in collection policy, with good credit control, will cause less eventual loss than a policy of promiscuous selling. The surveys unfortunately do not furnish any data on delinquencies, which would tell the true story, but the next semi-annual survey will probably enlighten us.

We believe that constant effort and increasing pressure from credit men and organizations and co-operation of kindred business lines will eventually establish more uniform terms and collection policies, but we have not as yet reached a point where we can lay down definite rules for credit and collection procedure, that will meet the requirements or satisfaction of all.

*Three Steps in Collections*—Fundamentally, we have, however, three essential steps in liquidating our accounts receivable, as follows:

1. Billing.
2. Follow-up.
3. Forced collection or repossession.

The majority of our customers pay regularly and fairly well within terms of sale, but each one pays according to an individual habit or approximately a certain number of days after receiving the bill. It is apparent, therefore, that money from our most attractive accounts is received in proportion to the promptness of rendering bills and statements. It is also important that the bills be legible, neat and state terms. If terms of all sales were distinctly explained and the thought conveyed to the buyer that payments will be expected in accordance with such terms, a good deal of misunderstanding and many delinquent accounts would be eliminated.

The installment buyer, as a rule, has a limited income and no surplus, and if he believes that payments of any amount, at his convenience, will be acceptable, the account will run delinquent.

In order to obtain proper accounting of revenue accounts, utilities usually keep separate accounts and ledgers for sales of current, merchandise and supplies, and many companies, for that reason, render separate monthly statements for each kind of account. A customer then may receive two or more statements from the same utility at different times during the month. This practice, of course, is very confusing to the average customer, as he does not understand the segregation of accounts, consumers', jobbing and miscellaneous. He probably will pay the first statement that is received, thinking that he has paid in full the amount which the company considers due at that time. When a later statement comes for some other item, it probably is laid aside for next month and the account unintentionally becomes delinquent.

The chief obstacle to a consolidated monthly statement is due to carrying the consumers' account in geographical order, and merchandise, supply and rental accounts alphabetically. This difficulty may be easily overcome by arranging the last mentioned accounts in accordance with the consumers' account numbers, so that merchandise installments and other charges may be posted on the light and power bills with less expense in time and stationery than in rendering separate statements. This method of billing has been found in practice to yield higher collection percentages, but, most important of all, is the fact that consolidated billing is more satisfactory to the customer and a satisfied customer is always more prompt in his payments.

The due dates of merchandise installments should be synchronized with the due date of the light bills to obtain the best result and to eliminate disputes. This is accomplished by furnishing salesmen and sales offices with a list of the average due dates of light bills for all meter-reading routes in their district.

The customer's account number indicates his meter reading route and the salesman obtains this information through credit approval or from the customer's light bill, which establishes the correct installment due date. If the customer insists on a different date than the scheduled due date for his service, the bookkeeper uses the first schedule date for collection purposes.

*Collections Depend on Follow-up*—The collection percentage is closely related to the follow-up scheme of delinquencies and the method used is naturally based on the business policy of the firm. Collection of installment accounts is usually controlled through the use of a card file arranged according to due dates and the follow-up consists of notices, letters and personal contact at regular intervals. The result is in ratio to the regularity of contact and demand for compliance with contract terms.

Considerable discussion has been carried on relative to the merits of form letters. It is granted that individual letters are by far the most desirable, provided the writer knows the customer and can appeal to his particular type or character, but when a firm has a thousand or more active contracts the expense of dictated letters is too high and the number of customers who are known to the writer in a personal way, is relatively small. Practical experience has taught us that short form letters, typed and not stenciled or mimeographed, are very effective and will bring desired result. These form letters should be made out in series and care should be taken that one series is not used two months in succession and that the use of the letters does not become too automatic and appear ridiculous. These letters should also embrace all other charges, including the service account, as separate collection efforts on various charges will cause unnecessary irritation.

*Meter Reading and Collecting*—When correspondence fails to bring results, then personal contact is necessary and for the utilities it is thought that the method used by a northwest utility is efficient and cheap in operation. This company has combined meter reading and collecting, to eliminate car mileage and time. The meter reader is furnished slips for all delinquent accounts, which are inserted in the meter reading book next to the sheet for the corresponding meter. This provides the required personal contact regularly each month and this arrangement is usually more satisfactory to the customer, as he soon becomes acquainted with the meter reader as a company representative and will discuss his problems.

*Educational Features*—The collection of installment accounts and the intelligent use of form letters offers a splendid opportunity for educational credit and collection work. An installment buyer who is inclined to become delinquent, usually is not in a position to pay two or more installments in a month, and if he is allowed to drag behind with his payments, will soon be several months in arrears. The solution of such an

account, of course, is to prevent it from becoming two months delinquent and this is accomplished only by conveying to the customer a realization of the fact that the installments will be expected as they fall due. The customer then will set aside sufficient money from his income to meet the monthly payments. A contract completed within specified time invariably spells repeat business, as he has more respect for the seller and finds himself in a happier mood than the customer who was allowed to run delinquent and was finally made to pay through forceful methods. The idea of the phrase, "First come is first served," can be effectively applied to installment collections. We frequently find that merchandise installment accounts that have been kept up to date, become regular payers on the service account, and that is when the educational feature bears fruit.

Forced collections or repossession procedures on installment sales fortunately constitute a very small percentage, if sales are made under proper credit control, and are handled individually according to the status of the accounts and the existing state laws. As a general rule the seller may take back the property, and the buyer forfeits all that he has paid. This rule, however, is subject to more or less regulation in the different states.

### Conclusions

The various methods adopted in granting credit and collecting receivables are chosen by each firm in accordance with its business policies and local conditions and each system is probably the most efficient for the concern involved. It is apparent, however, that the relationship of credits to collections is more important than the actual procedure employed in both functions, and the same rule applies to all.

When our credit losses are high and collection percentages are unsatisfactory, it is not necessarily due to inefficient collection methods, but is in most cases an indication of poor credit control or rating. If it were practical to grant credit on a 100 per cent basis, we would not have any collection problem—and for that reason the real solution lies in credit granting. An efficient collection department may do wonderful work on slow accounts, but is rather helpless in attempting to collect undesirable accounts, when it finds itself, under the most favorable conditions, in the position of a salvage department.

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## *Collection and Credit Methods and Merchandise Installment Accounts**

By F. L. NAGEL

THE credit and collection activities of public utility companies are usually governed by management policy, the location and class of customers served, competition, and regulations imposed by law—that is, regulatory body rules.

Until a comparatively short time ago, it was the almost universal practice of public utility companies to demand cash deposits to secure the payment of customer accounts, the amounts of which were usually at the discretion of the company. During the last decade, however, there has been a decided change in the manner of accepting customers' accounts, many companies having adopted a policy more akin to the credit practices of merchandise selling establishments.

The company is interested primarily in the ultimate payment of the service and merchandise account, and the retention of the customer's good will, and in this respect its problems are no more complicated than those of any other merchant. Authorities estimate that about 95 per cent of the people are honest and want to pay their bills, and that 83 per cent actually do pay them promptly, the balance failing because of conditions over which they have no control. Now, if 95 per cent, or even a smaller percentage, of your customers are honest, why should you penalize them because of the small number who are not? Until a few years ago, a credit man was practically unknown in the personnel of a public utility company. It was concluded that no credit problems existed, and rightfully so, if the utility company demanded cash as security before service was given to a customer. In this connection, it might also be said that good public relations were also lacking.

### Establishment of Credit

The modern way of conducting this phase of the public utilities business is to permit the customer to do business with the company on the same basis that he may with other merchants. Let him establish his credit. This may be done in a number of different ways, of which I will here cite one that I think would meet every condition. The customer applies for electric, gas, water or any other service that you may sell. Let your credit man, or whoever acts in this capacity, make inquiry. Has the customer ever been served by the company before? If he has, the problem is an easy one. The address and time where and when such service was rendered may be referred to and an immediate decision made. If his bills were reasonably promptly paid no security should be asked. If the customer has not previously had your service, obtain the address where, and the time when, he was served, and the name of the company that served him in some other city. An inquiry may then be sent to such company and in the meantime the customer taken, subject to final approval. If the reply to such inquiry warrants credit extension, nothing further need be done—otherwise, you may proceed to get security. Of course, it is possible that the company may lose a few dollars occasionally in the interim, but such loss may well be considered a good investment.

There will be many applications for service which will not require investigation, cases in which the application may be accepted without search. The application should contain space for filling in the customer's occupation. Such information has often been the means of passing on the customer's credit at a glance, with the exception, of course, that verification, if any doubt exists, should be made. It is obvious that a person occupying a position of trust, responsibility and apparent permanency may be trusted to pay his monthly service bills promptly. Then, too, the public utility business must be considered in comparison with the business of the general merchant. The utility business is based almost entirely on service rendered, and in the case of the residence customers, represents a necessary of life. The customer realizes that to insure uninterrupted service he must keep his accounts promptly paid. For this reason the residence customer is not, in my opinion, the utility company's big problem.

### Commercial Customer Is Biggest Risk

The difficulty of the credit and collection department of a public utility company is with the commercial customers. Each of these means a sizable load, the desire of the management and the aim of the sales depart-

* A report of the customers' records committee, Accounting Section.

ment; hence, much pressure is often brought to bear on the credit man to pass such accounts. Here, however, he should not permit himself to be stampeded. It is true that such business is very desirable. A commercial load, no matter how large, is, however, never desirable unless collection can ultimately be made. For without receiving compensation for our services, dividends cannot be paid and you know what follows. The commercial account, unless satisfactory credit can be established, should be secured, preferably by a cash deposit, in the absence of which a good surety may be accepted. I do not favor accepting guarantors or sureties, excepting as a last resort to avoid losing business. The acceptance of personal sureties is almost invariably a breeder of ill will, tending to break down good public relations. The surety, when called upon to pay, does it reluctantly and often bears a feeling of resentment against the company calling on him to pay, no matter how well he understood his obligation when he signed his name to the contract.

I do not agree with those who say that the demanding of cash security always creates antagonism towards the company. The problem of obtaining cash security, and at the same time retaining the customer's good will, is not one for inexperienced help. The employee should study the applicant. Information regarding the customer may be obtained in a number of different ways and to a large extent during his conversation with the customer. The credit man should be a student of psychology. Naturally, it is hard for a man who is coming to your city to open a restaurant or some other sort of business, to meet your demands for a deposit to secure a 60-day account amounting to from $50 to $100, and necessitating a deposit of $200. It is a drain on his resources, which the average person embarking on a business venture does not usually foresee. The problem can, however, be coped with, and usually to the customer's satisfaction. The relation of the utility business, its difficulties, and the necessity of supplying the customer usually for 30 days before a bill may be rendered, and the lapse of another ten or fifteen days before the account may be shut off for delinquency, should be brought to his attention. A complete understanding on the part of the credit man of the customer's problems should be manifested and a plan worked out with the customer. The account may be temporarily accepted with sufficient security to secure one or two weeks' billing and the meter read and bills collected at such periods, until such time as the customer can pay, either in a lump sum or by weekly installments, the amount of security necessary to cover 60 days' consumption. By making periodical payments on account of the deposit, the customer may be shown that he is saving his money and that he will be paid a substantial rate of interest during the time such deposit remains with the company.

Commercial references may also be accepted as a means of establishing the customer's credit. Very limited reliance should be placed on personal references. Their principal value lies in the fact that they are leads for locating debtors for collection purposes. There are other valuable sources of information which the credit man may use, among them being the mercantile reporting agencies, the local or nearest branch of the National Association of Credit Men, for commercial accounts, and of the National Retail Credit Association for retail accounts. Both of the latter named institutions maintain elaborate and efficient files with very complete information on the average credit seeker, in their respective classes.

### Trend Is Away from Deposits

The modern trend is away from the securing of customers' accounts either by cash deposit, surety or guarantor, excepting as an expedient after the customer has failed to establish his credit. Public utility companies operating in the State of California have long been hampered by what might be termed unscientific credit restrictions on the part of the state regulatory body. I am informed that these companies, through the electric light and gas associations in California, are now petitioning the California Railroad Commission for a revision of such rule and asking the privilege of conducting their business on a more modern basis. They recognize the absurdity of asking for security from every customer regardless of standing, and then being able to obtain security only of an amount totally inadequate and entirely devoid of any relationship to the amount of the customer's account.

There are companies now operating within the territory of this association, which I am told have a hard and fast rule to the effect that every customer must secure his account with a cash deposit. The mayor, the governor of the state, the banker and the large merchant, regardless of their financial responsibility, credit standing, or the duration of their residence in the community, are placed on the same plane with the transient, who may be entirely honest but who has not yet established his credit, and the habitual dead beat who never pays his bills when he can avoid doing so. The practice seems absurd, and I wonder how such companies can expect to build good public relations. It will be argued that the general policy places all of their customers on an equal plane. To me this seems impossible, as there is no equality in this respect. The theory may sound good in a political speech, but it has no place in sound business. We all know that the desire of the company is the payment of its bills, and the reason for security is the assurance of this. I am at a loss to understand how the demanding of a $5 deposit as security for his monthly lighting bill, can be taken without prejudice against the company by one whose credit standing in the community is unquestionable.

### Collections

Collection methods, like those of credit, vary with the office set-up and the policies of the different companies. As is the case with credits, the collector of public utility company accounts must be wide awake and make his collections with as little friction and inconvenience to the debtor as circumstances will permit. Public relations and good business methods should be considered in the collection of accounts. The insolvent of today may be a successful merchant of tomorrow, and the fairminded debtor will appreciate the necessity of the collection of accounts. The monthly electric, gas and water bill is a periodically recurring obligation and usually anticipated by the customer. In the case of the residence customer, it is for a necessary of life and as important to the maintenance of the family as is the food and drink which they consume. To deprive the household of this service is usually a serious matter, consequently the disconnecting of service as an expediency for collecting accounts should be resorted to only as an extreme and final measure, and then only after sufficient and timely notice of a specific time for such action has been given to the customer.

The paying of an accumulation of monthly bills is always distasteful and the larger the accumulated amounts, the harder is the drain on resources, consequently, a policy of close collection is desirable. In this connection, however, arises another difficulty and that is the cost of operation. The value of a credit and collection department to an organization is, of course, the difference between the actual bad debt losses suffered,

and the cost of making collections, as against the losses, which would be sustained should no credit and collection effort be made. Consequently, caution must be practiced not to permit the cost of collection to get so heavy as to nullify the benefits. A definite collection policy in keeping with good business practice is desirable.

The fact that a customer with a small monthly bill does not pay promptly upon receiving the statement, does not always argue that he is poor pay. If you will search your customers' ledgers, I am sure that you will find many customers whose monthly accounts average $3.00 or less, who do not pay them each month, some paying only once every three months, whose credit you would not question. Any extended collection effort on such customers would not only be wasted effort, but would result in the rupture of good public relations.

The collection of past due accounts in a public utility company may, therefore, well be classified as to their importance. It is good practice to vary the effort according to the amount of money involved; for instance, accounts for less that $5 per month and those between $5 and $10 or $15 per month, and bills above the latter amount might advantageously be placed in different classes for various degrees of activity, the first receiving the more lenient collection effort, and the degree of severity increasing as the outstanding amounts increase. By this I do not mean that no effort toward the collection of the smaller amounts should be made immediately after they become delinquent. On the contrary, each account that is past due should be called to the customer's attention. This may be done economically and effectively by means of small printed forms politely calling the customer's attention to the account attached to subsequent monthly bills. The expense of this activity is not large and may be done by a clerk, who could extract from bills ready for delivery to customers, such as contain back balances and attach thereto the proper notices.

### Two Collection Procedures

The set-up of collection procedure also is varied with many companies, and for this purpose I might cite two different systems. The first is the direct customer contact system; that is, a notice of delinquency of the account may be sent. Should the customer fail to pay within a set time after the notice is sent, the bill is referred to the collector, whose duty it is to call on the customer and collect, if possible. The second, we might call the office system of collection, which briefly is a follow-up of the preliminary notices by means of letters and telephone calls directed by men at the office. After sufficient notice has been given to the debtor, a definite date may be set, on which, unless payment has been made, the bill should be given to a collector (who is more properly called a shut-off man) with specific instructions to discontinue service in accordance with the last letter. The collector should not be authorized to deviate from such instructions, excepting in cases of illness or other extenuating circumstances. When the collector calls at the customer's premises for the purpose of discontinuing service, he should give no further extension and inform the customer that he is not authorized to do so. He may, however, tell the customer that extensions may be made only on authority from the office. In such cases it would be proper for him to suggest that the customer telephone to the office and talk to the collection man handling the account. Should such an extension be granted, he will, of course, follow such orders.

### Office System Preferred

I happen to be most familiar with the second system, as that is the system followed by the two companies by whom I am employed. There are several reasons why we prefer this system, namely, the economies effected and the results obtained. Efficient collectors, of the type that would properly represent a public utility company, must be paid a fairly good salary. The calls are scattered all over the company's territory, necessitating considerable time to travel from one customer to another. It is fair to say that in 25 per cent of such calls, at least, return calls must be made because of their inability to see the customer the first time. Then, when the collector does happen to make contact with the customer, the often-repeated reply of the housewife is that she does not pay the bills, that you must see her husband at "so and so," or "I am sorry I have no money in the house, but I will take the matter up with my husband tonight," thus wasting almost entirely the effort of the collector. Should the same collector make the subsequent calls, he is readily recognized through the curtain door and left to press the bell-button until he concludes that the call is another dud.

Contrast this with the office system of collection. The customer has received his several past due notices. They are delivered with the current bill or by the mail man. He has received several letters through the mail. These are read by the housewife and presented to the husband at night. The facts are there before him in black and white. He knows that he must act or be inconvenienced in having his service discontinued. Up to this point I believe the office system has been operated at the very low cost of a couple of printed notices attached to current bills, plus the effort of a couple of letters and the time of the office man, and I believe as much has been accomplished as has been done by the collector in the first system, after having made two and sometimes three calls. In addition to this, the calling of a collector at a customer's residence creates expensive collection habits. If a collector has called on a customer a couple of times, the customer is very apt to gain the impression that the collection by direct contact with the customer is part of the company's service, and he is thus very apt to form a habit of waiting for the collector to call and make such collection, which you must agree is an expensive practice.

### Pay Stations

A good practice to insure the prompt payment of bills, especially when the company's customers are spread over a large territory, is to establish pay stations in business establishments, at the most convenient locations at which the customer may pay the company's bills. This is a real accommodation, and especially to that class of customers which find it inconvenient to carry commercial bank accounts, thus permitting them to write checks, or to visit the office during office hours. In establishing such pay stations, preference should be given to drug stores because of the long hours during which such establishments conduct business, thus affording the customer the opportunity to pay his utility bill at all reasonable hours.

### Merchandise Installment Accounts

An ideal system from the collection department's point of view, would be to follow up collection of installment accounts immediately after delinquency, but unfortunately, there are other things to be considered in connection with public utility accounts, problems which the merchant does not have, and then, on the other hand, there are some advantages enjoyed by the utility company which are not open to the merchant.

Selling merchandise is an adjunct to the utility business and necessary to its continuous growth. The merchant's primary interest is the selling of appliances,

the incentive for which is the profit made on the sale, and if he is a progressive merchant, the creation of good will for future patronage. His interest, however, in the range and water heater which he sells, is closed when such article has been paid for, nor does the customer look to him because of any defect in the operation of such appliance (unless the defect be a major one). Thereafter he considers it his own and assumes responsibility for its proper operation. This is not so, however, with the appliance purchased from the utility company. Any failure in the satisfactory operation of an appliance always finds its way back in the form of a complaint; hence, we have sufficient excuse for the public utility company in the merchandising business, in order to insure the use by customers of the most efficient and modern appliances, thus encouraging the use of the company's service, building up the load, and reducing complaints to the minimum. Consequently, the credit and collection policies of the utility company in this respect differ very materially from those of the ordinary merchant.

Like most major household equipment, electrical appliances are usually sold under conditional sales contracts, by the terms of which the appliance remains the property of the company until payment in full has been made, whereupon the appliance becomes the customer's property. Because of this, the credit policy is usually a lenient one and based, of course, upon the credit standing of the applicant. A down payment of sufficient amount to cover the installation costs and any immediate depreciation should be obtained. Payments thereafter may be made on the monthly basis, the prevailing practice being to permit the balance to be paid over a period of from ten to eighteen months.

The manner of collection is also dependent upon the system set up by the selling companies, many of whom bill the installments separately each month; that is, a statement is sent to the customer for the respective due installments. A good system for the collection of merchandise accounts is to carry installments on the monthly service bill. This system has several advantages. First, it is economical; second, it brings to the attention of the customer the total amount owing the company each month; third, it is a constant reminder that the merchandise must be paid; fourth, should the customer call at the office and desire to pay his service bill only, a correction on the bill is usually necessary, thus affording an opportunity for the collection men to interview the customer and to urge the payment of the past due installment before too many installments accumulate.

A complete description of this system may be found in the report prepared for the customers' records committee of this association and presented at the meeting of 1930, to which you are respectfully referred. (See *Electrical West*, May 15, 1930, page 520.)

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## *The Value of Fixed Capital Records In Proceedings Before Regulatory Bodies**

THERE is an old adage which reads: "Never cross a bridge until you come to it." There is much virtue and food for thought in these few words. This admonition is of value to the worrying neurotic who fears his very shadow, but may be a dangerous one for the public utility business to follow. If the electrical industry is to continue to grow and prosper, especially in view of unfavorable criticism now directed against this business, it cannot close its eyes to some things taking place around it.

Contrary to the claim of certain people that regulation is breaking down, the actual facts, as this industry appreciates, indicate that regulation is becoming more severe and more intense.

Today, there is a demand in many of our states for stricter and more comprehensive regulatory laws. In fact, many states are considering complete revamping of regulatory laws and enforcement bodies. Not only will state regulation become more stringent, but federal regulation, not only of interstate business, but of holding and operating companies as well, looms as a possibility. This fact must be kept in mind, remembering the experience of the railroads of this country, which before federal regulation, enjoyed a period of comparative freedom from interference. Meager records were kept by the roads, because they could see no immediate demand for doing otherwise. With the tightening of regulation, the pendulum has swung the other way in their case and they are now compelled to keep minute detail of every penny expended in additions and betterments. They have been compelled to go back to 1914 and develop inventories of plant, property, and equipment, and not only bring them down to date, but keep them down to date. It is the consensus of opinion of those who have investigated the subject that this has cost the railroads of this country many, many millions of dollars more than would have been necessary had essential records been maintained year by year as they went along. The electrical industry should take a lesson from their experience. It can rest assured that not less but much more will be required of operating companies in the way of detail, not only to satisfy those regulatory bodies, but more especially to safeguard property and constitutional rights. Utilities may be compelled to prove confiscation, and that cannot be done on "judgment, estimates, and experience"; actual facts alone will suffice. This industry will be the storm center around which will revolve rate and possibly condemnation cases.

The determination of reasonableness of rates will always hinge on "value" or "investment." Either value or investment must be associated with physical property. This can only be done through the medium of property records, otherwise known as fixed capital records. Speaking of the desirability of proper fixed capital records in 1922, W. A. Jones, then chairman of the Accounting Section and now president of the National Electric Light Association, said:

"It is my opinion that there is too little attention given to the importance of associating physical property and values." (N.E.L.A. Proceedings 1922, Volume I, page 303.)

There seems to be this thought in the minds of some operators: "Never cross a bridge until you come to it." But, to those who have had experience on both sides of this argument, it is plain that the greater gain is on the side of preparedness. Preparedness does not mean the expenditure of large sums to develop elaborate records and extensive data in readiness to submit on a moment's notice, should occasion arise. Rather, preparedness is merely keeping one's house in order by properly recording the essential changes occurring in the physical properties from day to day and associating these physical changes with their correlative changes in value. In short, for the purpose of this report, "pre-

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Pacific Power & Light Company: W. J. Madigan.

paredness" means, "Do not put off until tomorrow what should be done today." In proceedings before regulatory bodies, it must be apparent that the cost to the utility and the cost to the state is in direct proportion to the time element. Long drawn out cases have cost the electrical industry and the ratepayers of this country millions of dollars. Long extended cases are invariably due to lack of clarity in the records or to no record at all. In the absence of fixed capital records, the first essential in a rate or valuation proceeding is to have made a complete inventory and appraisal of the utility's properties. This not only takes time, and time is money, but no appraisal or inventory made under pressure can ever be as complete, satisfactory, or accurate as one maintained during the life of the property.

An appraisal made by an outside engineer or firm is valuable as a check against the fixed capital records but such appraisal on its own merits alone is subject to attack because of omissions, claimed by the utility, and to inflated values, claimed by the other parties to a case. Some executives have been prejudiced against maintaining fixed capital records systems, feeling that their only purpose was a running inventory serving as ammunition in case of rate battles. If that were the only use for such records there might be some justification, in the case of small utilities, for this attitude; but that is not the main purpose of such data, as everyone knows who has worked with fixed capital records systems. However, this report treats of their value in that one respect only. In any proceeding before a regulatory body, "value" must be determined and considered. "Value" must be representative chiefly of physical property, or fixed capital. If a record of physical property or fixed capital is not available, one must be developed for this purpose.

When a rate case looms before a utility, it is the fixed capital record which is the utility's first line of defence and when we consider the trend of political agitation, the value of the existence of fixed capital records must be obvious.

### Cheap Proof Furnished by Adequate Records

In a proceeding before a regulatory body the first fact to be proved is the actual existence of property claimed and whether or not such property is used and useful in public service. With a property worth many millions of dollars, the determination of this fact is a task of no mean proportions. In the absence of down-to-date records, this means an item by item field inventory and appraisal by two individual groups of engineers and appraisers—one representing the utilities and the other the regulatory bodies, with a possibility of a third group representing an intervener such as a municipality. Obviously, this is duplication; needless duplication is always waste, and waste is money lost. A great amount of time is consumed in such procedure —and time costs money. With an adequate fixed capital records system available, no time is lost, and little money is spent to prove quickly and unequivocally the five major facts pertinent to and demanded in such cases or proceedings. These facts which must be proved are as follows:

1. The actual existence of the property claimed.
2. Whether or not such property is used and useful in public service.
3. Its actual age in service. (To assist in the determination of depreciation.)
4. Its actual cost, or investment involved.
5. An itemized inventory, easily verified, which can be readily priced for reproduction cost new studies.

### Value of Photostats

If suitable fixed capital records are available, it will be unnecessary in such proceeding for representatives of either the utility, the regulatory body, or other parties to, or interveners in a case, to make a field inventory in order to develop the data pertaining to the above mentioned subjects. All that is required is to have the fixed capital records photographed (photostated). This is quickly done and at little cost, producing exact duplicates of the original records, which can easily be taken into the field and every item quickly checked as to its existence and its usefulness in public service. Any special notes regarding the condition or other pertinent data of any of the property or equipment can be made on these photostats. From these photostats of the fixed capital records, the regulatory engineers or accountants can readily check the vouchers or records to verify the cost of the investment shown on the record. The age in service can also be verified in this manner for depreciation studies.

There is a further advantage that such photostats of actual records give, namely, that all parties to the case can readily agree as to the facts regarding the properties and each party will have an identical inventory upon which to base his data and arguments. This fact, alone, saves a great amount of time and eliminates much discussion in a rate or valuation proceeding.

Another advantage is the fact that if the records have been properly maintained, the retirements shown thereon are conclusive proof of the utility's earnest desire to see that all removals and abandonments of property have been written off the books.

Such photostats of fixed capital records with the verification of the investigators, will stand the acid test before any commission or court in the land, constituting exhibits without flaw or error. In this manner, all guess-work, all estimates, all omissions have been eliminated with a minimum expense of time and money. The utility's arguments, instead of being based on "judgment" and "experience," two uncertain factors, are based upon "facts." Fixed capital records constitute historical development of factual evidence, rather than a development of "expert" evidence. Such records provide the means of readily proving "facts" to the satisfaction of investigators, regulatory bodies and courts. It is facts, not estimates or judgment which will support a utility's contention without successful contradiction.

H. M. Brundage, vice-president of the Consolidated Gas Company of New York, who has experienced many unpleasant and costly rate cases, said, in expressing himself on this subject and urging the utilities to develop and maintain better and more detailed and accurate records:

> "Forewarned is forearmed." If you men knew, thoroughly, when you were starting a rate case . . . . just what you were facing, what you would be obliged to prove, the methods by which you would have to prove it . . . ; if you knew all these things before you started, you would be in far better shape to fight such a case as we went through, than you would otherwise.

To such companies these experiences have proved beyond the shadow of a doubt the value of maintaining proper records which can be used on short notice to protect the property of a company and the investment of the stockholders.

Rate cases are grueling struggles and severely test, not only the endurance of the personnel, but the records as well. We often hear it said, "The cost of maintaining such fixed capital records is prohibitive." Is the cost prohibitive, of perhaps a maximum of one-fourth of one per cent of the investment involved, to *originate* a fixed capital record system; and from one-tenth to one-one-hundredth of one per cent of the investment to *maintain* such records annually, if it is a means of retaining in the rate base hundreds of thous-

ands of dollars, which otherwise are invariably lost to the stockholders because of the utility's inability to prove facts conclusively? It is an experienced fact that the cost of maintaining suitable fixed capital records, if for no other purpose than for proceedings before regulatory bodies, is actually less over a period of years than the cost to take an inventory and appraisal when the occasion demands it.

### Summary

This committee sums up the advantages and value of fixed capital records in proceedings before regulatory bodies as follows:

1. Saving of time; an important element in such proceedings.
2. Saving in cost over special inventories and appraisals.
3. Proof of retirements having been made of property removed or abandoned.
4. The actual existence of the property claimed.
5. The fact that such property is actually used and useful in public service.
6. Proof of age and condition for depreciation studies.
7. The actual cost of, or investment in, fixed capital.
8. An itemized inventory which provides ready means of reproducing the actual property on a reproduction cost new basis.
9. Provides means of a common basis of facts which can be agreed upon and used by all parties to such a proceeding.
10. Basis for exhibits, not only before regulatory bodies, but evidence which cannot be contradicted before any court.
11. Means of eliminating guess-work, estimates, judgment and experience, substituting therefore actual facts.
12. Provides a factual basis for developing exhibits or claims which will meet all of the requirements of Supreme Court decisions in valuation proceedings.

# ADMINISTRATION AND CONTROL OF BUDGET EXPENDITURES*

BUDGET administration and the control of budget expenditures represent in general the entire scope and functions of a budget. Undoubtedly most utilities employ some type of long term forecast, possibly extending over a five, ten, or fifteen-year period. The annual budget is also quite generally adhered to and consists of estimate of earnings, expenses, taxes, interest, and construction, together with the estimate of monthly cash requirements. It is assumed that every utility now follows some definite budget procedure which is considered best adapted to that company's requirements. The fundamental budget plans of up-to-date utilities will usually follow a fairly consistent trend. The successful administration of a budget is by far the most important element in determining if the time and labor expended in maintaining a budget system is justified. Our committee has not attempted to treat the subject of the budget in its particularly wide meaning, but it has confined itself to the study of a few fundamental principles, which appear very essential in the mechanics of preparing the budget estimates and operating within those estimates.

We have confined our study to two sections: The first, "Creating Budget Consciousness"; the second, "The Development and Application of a Register of Maturing Obligations," which is often termed a "Commitment Register."

### Creating Budget Consciousness

The primary purpose of a budget is completely lost unless it is administered and followed through in the spirit of its original intent. The assumption that a budget is prepared on the principle that it is merely an estimate and may be altered at will, should be removed from the minds of those concerned with the preparation and operation of a budget. How many times we have heard the expression, "Since this is only an estimate, one guess is as good as another." It cannot be said that this somewhat indifferent feeling is due entirely to the individuals preparing the estimates. We would venture the suggestion that the significance of conscientious estimating would be recognized and appreciated if a proper follow-up were made on the basis of actual performances. Too often departments feel that once their estimates are made up, they are soon disregarded and the time spent by them has been dutifully wasted.

In general there is an apparent lack of the intangible something termed "budget consciousness." Regardless of the manner in which any budget may be compiled, it will undoubtedly fail of its purpose unless the individuals responsible for its control are firm believers in the purposes and benefits of a budget and its proper administration. Budget consciousness will not happen; it must be developed. The question arises, what are the methods of developing this so-called budget consciousness?

### Centralized Head Necessary

Essentially the budget functions must be directed from a centralized head. Perhaps your company has delegated the administration to a budget department. Possibly the responsibility in other companies is centered around a certain group in the accounting department, or perhaps the treasurer or one of the administrative officers is supervising budget control. It is our impression that too often the responsibility of budget control is placed with a general group of individuals or with an officer whose time is partially taken up with other duties and who cannot take sufficient effort for the development of a successful budget administration.

The importance of budget control is so great, that, at least in a sizable concern, the responsibility of its administration should be centered on one individual, a budget director or supervisor. In smaller companies the control might be delegated to a statistician or at least to some centralized unit. We have named the statistician because of his general departmental knowledge and for the reason that final and comparative cost figures are generally compiled under his supervision. The budget director, if we should so term him, would naturally operate in connection with the Accounting Section or would at least have reference to all cost data compiled by the accounting and statistical departments, in order to eliminate duplication of effort. It would seem that such an individual would have to be very well grounded in all departments of the industry. He would be the one to develop through different channels that fundamental requirement which makes a budget system successful, budget consciousness. It is not our thought that a budget cannot be administered successfully by other methods, but we maintain that the control must be delegated to a definite head and

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Puget Sound Power & Light Company: H. B. Johnson.

that the administration thereof would reflect accordingly.

Thus far we have attempted to establish two definite points—the fundamental necessity of budget consciousness, and the promotion of budget consciousness by means of a budget director. We shall now describe a few methods of preparing estimates, and the follow-through of these estimates, which, if properly supervised, will materially aid in establishing budget consciousness and correspondingly provide an intelligent and profitable control of budget expenditures.

We refer here only to the expense and construction budgets.

### Expense Budget

Departments would be required to base their expense estimates on actual detailed performances, instead of on previous year's results plus an average increase or decrease. Estimates might be segregated between payroll, material and supplies and miscellaneous. Payroll should state number of employees, rate and duties. The duties of each employee should be available for the inspection of the budget director, since he will be responsible for eliminating duplications of work, which situation is naturally bound to exist in a large organization. Very often two identical sets of records may be maintained or two departments may be duplicating certain functions, and the facts have never come to the attention of either department head. The budget officer would undoubtedly have opportunities to combine duties and simplify methods. It would be his work to test the practicability of continuing the preparation of certain reports. We recognize the fact that in every organization certain reports are rendered each month, possibly because of precedent, which, if traced down, would be found to be noted and filed, perhaps never used for any practical purpose.

With estimates prepared in the above manner, the department supervisor in charge is able to identify over-runs or under-runs at the end of each period. He will feel entirely responsible for operating within his estimate, inasmuch as it is realized that the budget director has available the detailed items which constitute the original estimate. This practice of preparing itemized estimates may appear to represent unnecessary refinement, but on the other hand, one must be able definitely to spot individual items, if the responsibility of control is to be determined.

It sometimes occurs that the estimates of various departments are included in the same expense group of expenses. For instance, one is supervisor of the transmission system, another supervisor of the overhead distribution system and a third in charge of underground. One would not have to stretch his imagination very far before the complications of preparing estimates would become evident. There is, of course, certain overlapping of departments, duplications of duties and quite often the responsibility is not centered. It is recommended that the expense budget be prepared in the regular manner, but that it contain a separate allocation of the expenses which affect more than one department head.

The maintenance section of expenses should be prepared on the basis of specific jobs contemplated. Possibly one may think an average rate of increased costs would be a justified estimate. Only by preparing a detailed analysis of the major maintenance jobs can a definite comparison be made with the actual costs. The customary explanation now prevailing for over-runs on maintenance is to the effect that maintenance work greater than estimated would be eliminated. The maintenance crews would correspondingly recognize the desirability of preparing estimates that could be reasonably adhered to and estimates which they would pride themselves on their ability to operate within.

A plan which is quite drastic, but which would control expenses, especially maintenance, would be that of sanctioning the expenditures of funds during the month in which they were originally authorized. Under this plan, if a department's expenses were considerably under the estimate in one month, this saving could not be taken advantage of in a succeeding period. This would be a very definite method of holding down expenses to estimates and would cause all department heads to recognize the benefits of submitting only the necessary requirements.

In cases where the construction division handles the maintenance as well as the construction work, and estimates both new work and maintenance items, they would at all times know exactly the maintenance work authorized but which was uncompleted and therefore could better regulate the number of crews required,

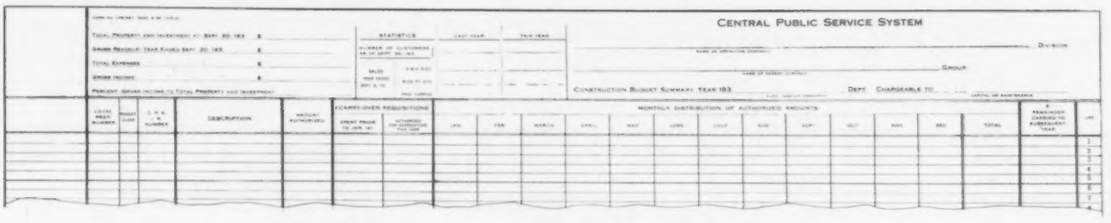



*Fig. 1. Proposed forms for preparing construction estimates.*

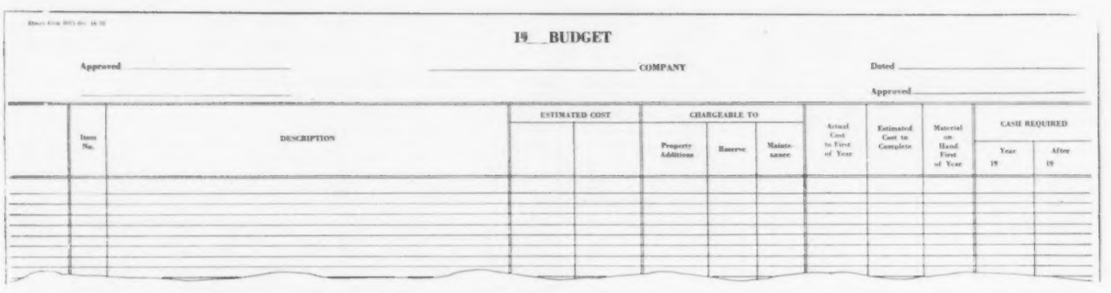
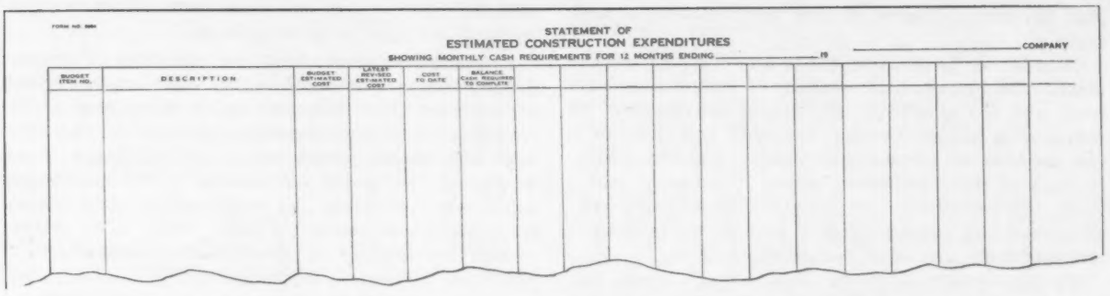



*Fig. 2. One of the proposed forms for preparing annual or semi-annual construction estimates.*



STATEMENT OF
ESTIMATED CONSTRUCTION EXPENDITURES
SHOWING MONTHLY CASH REQUIREMENTS FOR 12 MONTHS ENDING _____ 19 _____ COMPANY

| BUDGET ITEM NO. | DESCRIPTION | BUDGET ESTIMATED COST | LATEST REVISED ESTIMATED COST | COST TO DATE | BALANCE CASH REQUIRED TO COMPLETE | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | |

*Fig. 3. Proposed form for statement of estimated construction expenditures.*

which accordingly would eliminate the necessity of maintaining a fixed number of crews, that policy being based on the assumption that when construction work was lagging, the entire force could be delegated to maintenance jobs.

### Construction Budget

In the construction division, greater variations in estimates occur, perhaps, than in any other department. Funds are made available to take care of such requirements during the month in which work is expected to be done, and for this reason the construction estimates are of special importance in the control of cash. An interesting suggested procedure would be to prepare a summary of actual expenditures in comparison to estimates over a period of time, and then calculate the interest charges accruing from unnecessary variations. Thus the construction department would recognize the meaning of definite estimating and also the fact that their estimates form the basis of cash control.

Proposed construction requirements should be divided on a twelve months' basis. The cash required by months is very often established by an optional division, possibly by taking the total for the year and dividing by twelve, but making allowances for unusual peak months. Inasmuch as this requirement represents a good portion of the cash outlay for the year, a very definite breakdown should be made. The construction department should chart each construction project individually and designate the months during which the work is to be done. This report should be checked by the budget director each month to determine if original estimates have been given proper consideration. Conditions may arise which will prevent the following out

FORECAST OF CASH RECEIPTS AND DISBURSEMENTS

BY MONTHS FOR THE TWELVE MONTHS ENDING DECEMBER 31 193_____

(NAME OF COMPANY) DIVISION

| | MONTH | RECEIPTS | DISBURSEMENTS | | | | | | | | | BALANCE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A LOCAL COLLECTIONS | B EXPENSES EXCLUDING TAXES | C NET RECEIPTS A MINUS B | D TAXES PAYABLE (SCHEDULE I) | E INCOME CHARGES (SCHEDULE J) | F CONSTRUCTION REQUIREMENTS | G NOTES PAYABLE (SCHEDULE S) | H OTHER DISBURSEMENTS (SCHEDULE J) | I TOTAL D TO H | J | K MONTHLY C MINUS I | L ACCUMULATED | |
| 1 | Cash Balance | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | XXXX | | 1 |
| 2 | January | | | | | | | | | | | | | 2 |
| 3 | February | | | | | | | | | | | | | 3 |
| 4 | March | | | | | | | | | | | | | 4 |
| 5 | April | | | | | | | | | | | | | 5 |
| 6 | May | | | | | | | | | | | | | 6 |
| 7 | June | | | | | | | | | | | | | 7 |
| 8 | Totals—1st 6 Mo. | | | | | | | | | | | | | 8 |
| 9 | July | | | | | | | | | | | | | 9 |
| 10 | August | | | | | | | | | | | | | 10 |
| 11 | September | | | | | | | | | | | | | 11 |
| 12 | October | | | | | | | | | | | | | 12 |
| 13 | November | | | | | | | | | | | | | 13 |
| 14 | December | | | | | | | | | | | | | 14 |
| 15 | Total—2nd 6 Mo. | | | | | | | | | | | | | 15 |
| 16 | Total—12 Mo. | | | | | | | | | | | | | 16 |

| | MONTH | LOCAL COLLECTIONS | | | | | | | | EXPENSES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | OPERATING | MERCHANDISE SALES | INTEREST | DIVIDENDS | | | | TOTAL COLLECTIONS | OPERATING EXCLUDING TAXES | MERCHANDISE SALES COST | | TOTAL EXPENSES | |
| 1 | January | | | | | | | | | | | | | 1 |
| 2 | February | | | | | | | | | | | | | 2 |
| 3 | March | | | | | | | | | | | | | 3 |
| 4 | April | | | | | | | | | | | | | 4 |
| 5 | May | | | | | | | | | | | | | 5 |
| 6 | June | | | | | | | | | | | | | 6 |
| 7 | Total—1st 6 Mo. | | | | | | | | | | | | | 7 |
| 8 | July | | | | | | | | | | | | | 8 |
| 9 | August | | | | | | | | | | | | | 9 |
| 10 | September | | | | | | | | | | | | | 10 |
| 11 | October | | | | | | | | | | | | | 11 |
| 12 | November | | | | | | | | | | | | | 12 |
| 13 | December | | | | | | | | | | | | | 13 |
| 14 | Total—2nd 6 Mo. | | | | | | | | | | | | | 14 |
| 15 | Total—12 Mo. | | | | | | | | | | | | | 15 |
| | REMARKS: | | | | | | | | | | | | | |

*Fig. 4. Form for summary of monthly cash requirements.*

of the original estimate. Where that condition becomes apparent and is of enough importance to affect cash requirements, a revision should be made by items, by month, which will become the basis for future requirements, at least until another revision has been found necessary.

Proposed forms for preparing construction estimates are shown in Figs. 1 to 3. These may be of benefit to companies that have not previously established a procedure along the lines suggested. These forms are adopted for the yearly, or semi-annual construction estimates, or for such other periods as conditions may demand.

### Register of Maturing Obligations

After all preliminary data for the budget have been compiled, the estimates of each section are combined and consolidated into a summary of monthly cash requirements, Fig. 4. This summary or recapitulation represents the basis of the company's financial program. It contains the estimate of cash on hand, the amount to be received from earnings, dividends, sale of stock, and various other sources. The amounts required for operation, maintenance, taxes, interest, dividends, construction, and retirement of debt, having been taken into consideration, a surplus or deficit is determined.

Each month, or at least periodically, the financial officer of the company wishes to determine the amount of ready cash necessary to carry out the budget program and meet all obligations promptly and economically. He will base his estimate of cash from earnings on the current collection situation, he will have reports predicting the trend of security sales and he will assume that expenses and general construction requirements will run fairly close to the estimate. In the ordinary concern, other cash requirements will need to be picked up at random. Possibly the financial officer, having no definite information at hand, will find it necessary to confer with various department heads regarding their requirements for the ensuing period. Officers of subsidiary companies may require additional cash; perhaps a large amount of fuel has been ordered that was not anticipated in the original estimate; installations of large pieces of equipment may take place in advance of the estimated schedule; payments of dividends may vary between periods and from the original estimate; and legislation may be passed authorizing a change of schedule for tax payments.

Items of the foregoing nature usually represent large sums of money and for that reason they should be set up on records which will provide a method of securing an accurate cash control, and that control in the final analysis determines interest charges.

A register form has been suggested, which may be used advantageously for obligations that mature, other than on a regular current basis. It is designed as a convenient means of recording unusual and unexpected items not ordinarily recorded in the company's books until payment has been made. These items have a very direct bearing on budget control.

For example, the price of copper or fuel may be very favorable and it may be desired to place a large order for future delivery. Payment may be arranged on delivery or on a 60 or 90-day basis. Obligations of this nature should be recorded, in order that the very best control of cash requirements may be attained. If the committments are not recorded, the budget supervisor must rely entirely on the memory of the department heads. In the case of placing orders for the delivery of power plant machinery, the register recording this obligation would need to be closely co-ordinated with the construction estimate so that the possibility of duplication would be eliminated.

A register of maturing obligations may be divided into two sections. One section would be the means of following up items recorded on the books of account, and another section for recording items of which no record has been made on the company books of account.

Below are listed items which may be followed up from books of account:

1. Long term debt.
2. Bank borrowings.
3. Sinking funds.
4. Interest maturities.
5. Dividends payable.
6. Advances to subsidiary companies.
7. Real estate purchased on contract.
8. Funds deposited with trustees for release of property.

Items which may be followed up from sources other than the books of account are as follows:

1. Large items of equipment requiring considerable time to manufacture, which are ordered in advance of time they will be received and paid for.
2. Copper and fuel ordered for future delivery.
3. Contracts for construction of power plants, transmission lines and substations which require periodic cash advances during the construction period.
4. Transformers shipped to manufacturers for rebuilding or rewinding.
5. Power contracted for future delivery.
6. Quarterly income tax payments.
7. Real estate and personal property tax payments.
8. Improvement assessments.

These items may be classified in the register of maturing obligations somewhat as follows:

1. Security obligations.
2. Interest obligations.
3. Dividend obligations.
4. Construction obligations.
5. Operating obligations.
6. Tax obligations.

This record should be maintained by the budget director or in the department which has supervision of the budget estimates, depending of course on the size and operations of the utility organization. It should be brought up to date each month, incorporating such additions as are necessary. Additions or changes would come from the various departments concerned, and for that reason the budget director would be required to maintain the confidence of department heads affected, in order that he would receive notification of all expected cash requirements. This form will be found useful to departments, as for instance when the construction division finds it desirable to keep a running check on material ordered over the period of the construction of a large project, and wishes to know at all times the balance of equipment required on which no commitment has been made.

### Form Recommended

The size of the proposed form may be determined according to the needs of a particular company. Space should be provided in the order named for the date the obligation is registered, the description of obligation, the authority and reference, the total amount of the obligation, the date the obligation is due, and the months of the year. Under the name of each month in the year, columns should be provided for the estimated amount, the actual amount and the date paid.

Two sheets may be required for the use of this form in order that sufficient space will be available for the three columns: estimated amount, actual amount, and date paid, which columns should be shown directly under the name of each month.

It is understood that this record could not possibly be a balancing record, and would not necessarily replace any of the balancing records already in use.

# CLASSIFICATION OF ACCOUNTS*

AT the time this committee was formed it was suggested that we direct our energies during the year 1930 toward securing the adoption of the National Association of Railway and Utilities Commissioners' classification of accounts in those states which have not already adopted it, and to promoting the use of the standard form of report recommended in conjunction with this classification. Recognizing that this objective might not be reached for some time, your committee secured all previous correspondence between the 1929 committee and the officials of the various public service commissions and started a permanent file by states to be passed on to succeeding committee chairmen.

Comparative studies were prepared, outlining the differences in the information required and method of presentation and these were furnished to the public service commissions.

In presenting the report for adoption, the question was brought up by one of the commission representatives as to the detail required from the smaller companies in reporting their operating expenses on the standard report. The classification was accordingly decoded, showing separately the information to be submitted by Class B, Class C, and Class D companies, which it is hoped will facilitate the future study of the matter by the various commissions.

Our efforts were met with consideration by the commissions approached and we were assured that the subject matter would be studied with a view to ultimate action. Although no definite results were accomplished this year, we believe that the feeling is growing among commissioners and their accounting representatives, that the interest of both the commission and the utility can best be served by the adoption of uniform accounting methods.

* Report of the classification of accounts committee, Accounting Section. R. W. Miller, Idaho Power Company, chairman.
Idaho Power Company: A. W. Ashton.
Montana Power Company: J. R. Thomas.
Pacific Power & Light Company: Will T. Neill.
Utah Power & Light Company: Henry Mann.
The Washington Water Power Company: C. E. Gieseker.

# PURCHASING AND STOREROOM*

THE purchasing and storeroom committee took up during the year a study of the application of machines to stores accounting, accounting for merchandise stores, the salvage and disposal of obsolete supplies and scraps, and the value of executive instruction to stores departments.

The result of these studies are embodied in the following five papers.

* Report of the purchasing and storeroom committee, Accounting Section. O. W. Bennett, Puget Sound Power & Light Company, chairman. J. S. Ruppe, Puget Sound Power & Light Company, vice-chairman.
Idaho Power Company: W. L. Baker.
Mountain States Power Company: Harry Anderson.
Pacific Northwest Public Service Company: I. D. Murfield.
Pacific Power & Light Company: Clause R. Groth, J. M. Laflin.

## *Machine Method of Stores Accounting**

By I. D. MURFIELD

UNTIL recent years, the application of machines in the accounting field was a dream, but today the dream is a reality, and now we find the application of machines to practically all branches of the accounting work, performing the various operations as though they were human. All that is missing, is the mind.

### Application of Machines for Stores Accounting

It must be borne in mind that machines are designed, built, calibrated, and set to perform a certain operation and give a definite result. This, of course, requires many changes from the manual method to outline the routine of the work to conform with the machine requirements. I will not attempt at this time to go into detail on this subject, except to say that machine posting eliminates practically all detail found in long hand methods, resulting in speed of operation. The two outstanding advantages of machine stores accounting are the automatic proofs, and the daily balancing of postings on the records. To accomplish these results, the following set-up is necessary:

1. Stores requisitions must be single item and of proper size to meet machine requirement, and show one account chargeable.
2. Arrangement of stock values based on even unit basis is necessary for proof posting.
3. Arrangement also of stock units is necessary to prove correctness of posting on records. By this I mean, for example, 15 units at 0.0776 per unit equals 1.164 or, in other words, the result ends in a fraction. To overcome this condition and make it possible to prove the posting, it is necessary to adjust the item to the nearest even unit value, which in this case would be .08. The same rule applies to the quantities issued, eliminating all fractions of pounds, feet, etc.

To overcome any variations arising from such adjustments of the stock unit values, a card is carried, known as an adjustment card, on which all such adjustment amounts are posted, either as a debit or a credit, and the net value of the adjustment card is considered as a part of the total stock value. As time goes on, the debt and credit side of the adjustment card will equalize in money value or near enough to permit of an adjustment being made, clearing the amount carried without disturbing the individual stock values.

### Group Posting to Records Covering Disbursements

Group posting seems the logical plan, rather than individual item posting. This method saves time and record space. Inasmuch as the cost department of the auditing department has on hand at all times, for inspection and reference, the individual requisitions, it would appear as a duplication of work to post the individual requisitions. I am in favor of group posting on the stock record control cards.

### Advantages of Centralized Stock Records

Much can be said in favor of centralized stock records. The two principal advantages are, first, that you have a centralized control, and second, that it allows for closer supervision over the stock by those held directly responsible, giving them a chance to study the movements of the various articles carried. This will lead more often to standardization, thus reducing obsolescence, which in the final analysis means losses.

* A report of the purchasing and storeroom committee, Accounting Section.

### What Information Should Stock Records Show, Other Than Receipt, Disbursement, and Balance on Hand, With Reference to Information Beneficial to General Storekeeper, or Executives, Such as the Inactive Stock, Obsolete Stock, Emergency Stock, Etc.

In commenting on this subject, it is my firm opinion, that all stock of this nature should be set up on stock cards as a special group, in order that special data can readily be prepared on the group as a whole, or on the individual item if desired. The manner of posting such records should be by machine the same as regular stock. It is my idea, however, that all such groups should be considered as a part of the general supply account, and merely segregated into a special group for information purposes only. Emergency stocks should carry set standards on each item with reference to quantities, and should be maintained at all times, except in cases where the article is no longer needed for emergency purposes. When an article is withdrawn from emergency stock, the amount withdrawn should be immediately replaced, or as soon thereafter as possible, bringing the quantity again back to the standard. A requisition for the required amount should be drawn on the general stock, charging the account covering the work.

### How Often Should Records be Posted

To receive the best results from any system, it is necessary that the posting be up to the minute, or as nearly so as possible, and, therefore, I say that daily posting is the ideal plan, if it can be so arranged.

### Advantages and Disadvantages of a Centralized Clerical Force

I firmly advocate, where physically possible, the centralizing of all storeroom clerical force, for the reason that I favor the record of the stock. It allows for closer supervision and clears the records through one channel.

### Control of Investment in Supplies

This phase of stores accounting, to my mind, is one that should be given the most careful consideration and attention of those in charge. Investments in supplies represent actual cash in material form, and deserve the same consideration that is given the cash on hand. Too often, purchases of new materials are made, when something already in stock of like nature could well be substituted and serve the purpose, and thereby save the unnecessary expenditure. It should be the duty of each department head to make a personal inspection periodically, of the various articles in the storerooms carried for his department, putting his stamp of approval on items that he knows can be used for given purposes as substitutes for regular standard material, and he should also instruct the storekeeper to give out such articles whenever possible. This would do more in helping to reduce the investment in stock than almost any other plan, and would also help materially in relieving the factor of obsolescence.

Establishment of maximum and minimum quantities to be carried also would accomplish much in reducing the investment in supplies. It should be the duty of the department head to furnish this information and only after careful study has been made, based on general averages used over a given period of time. Replenishment of stock under this arrangement should require that all orders, before purchase is made, be referred to the department head for approval. His attention is thereby called at the time when the minimum is reached, and he has the opportunity of making any changes he may care to make for articles of later design better suited for his purposes.

In conclusion, I wish to say that I firmly believe that machine methods of stores accounting will soon replace the hand methods in all large organizations, where speed and accuracy are required, and where the watchword is, "efficiency and economy."

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## *Merchandise Stores Accounting**

By W. L. BAKER

THIS report is based on questions raised by the national committee.

*Question*—Material purchased and billed as complete units but comprising several parts. Parts are interchangeable and subject to use, other than to make up the complete assembly. As the most economical way to purchase this equipment is as complete assemblies, what arrangements are made with the manufacturer so as to get unit prices on the parts which go to make up these assemblies?

*Answer*—There is no question that better prices are available to the purchaser of merchandise where the merchandise or material is purchased as a complete item or assembly, as against the securing or purchasing of individual parts which go to make up a complete unit or assembly at prevailing parts list prices.

In order to secure the proper unit cost prices on the parts which go to make up complete assemblies, it is necessary, when issuing your formal purchase orders to cover, that same bear notation to the effect that where complete assemblies are involved, the manufacturer, in rendering invoices, must show the quantities and style numbers of the parts which go to make up the assembly, as well as setting forth the respective unit prices applicable to the individual parts, which, when added together, will total the unit price applicable for the complete assembly.

We considered it might be of interest to know that in connection with this question, we contacted two each of the leading manufacturers of electric ranges and washers, with the idea in mind that further savings could be accomplished by the securing of complete items of electric ranges and washing machines knocked down.

Naturally, it should be understood that by purchasing complete units in this manner the purchaser would accumulate in his stock certain items of a very slow moving character, but we considered that, if an additional saving could be enjoyed, it might possibly offset the added carrying cost resulting from such slow moving items.

The replies received, however, indicated, without exception, that this procedure would not be entirely satisfactory to the manufacturer on account of increased, rather than decreased, costs involved. Says one manufacturer:

> After parts are manufactured, these are delivered to the assembly conveyor in large boxes, and in case of large parts, piled on trucks. A certain portion of manufactured parts are delivered to the parts department stock. There they are wrapped, packed and placed in storage ready for shipment when orders come in.
>
> When parts orders are received the material is picked, packed and shipped. This necessitates additional handling and packing, which is more costly than assembling and crating a complete unit. The fact is that with most orders for a few parts the cost of extra handling and packing

* A report of the purchasing and storeroom committee, Accounting Section.

greatly exceeds the cost of the material and labor to crate a complete unit.

*Question*—What is the most practical method of handling material to be assembled and later issued as a complete unit?

*Answer*—There are possibly many different procedures which involve more or less practical methods for this task, but the most practical method, as we view it, is that of handling the material required through the medium of machine shop operations.

In this way all materials and labor involved are shown in connection with shop order issued and, accordingly, a true analysis of the unit cost is available.

*Question*—Discrepancies in stocks, records, and how far to go in locating discrepancies. No one seems to be able to say just how far investigations should reach to discover shortages and overages.

*Answer*—Action in this respect, we believe, is entirely dependent on the kind or type of stores system in effect.

We appreciate that while it is the intention and desire of all concerned to work out a standardization of methods which can be readily adopted by any member company desirous of obtaining the maximum in satisfactory results, there still exist several different stores systems among the member companies. So far the results obtained from the different systems indicate a fairly satisfactory average, but there remain some very desirable results yet to be obtained.

Where the operating company has installed a general office stores record, either ledger or card, which embodies a complete record of each individual item moving through stores, it is possible, we believe, to carry on a fairly extensive investigation pertaining to shortages and overages, without incurring a big item of expense. This can be accomplished through the medium of a form having a space provided for the proper description of the items requiring investigation, together with data indicating the amounts as charged and credited at the respective stores point, and with the balance on hand as of date. This information is compiled from the general office stores record and mailed the field office concerned for audit and check.

Invariably, this procedure, when followed, will bring to light the exact discrepancies as they actually exist. Any action desired or determined upon can then be taken, as full knowledge of the facts is then available.

Where no general office stores records are maintained, the records being confined to the respective local offices and presumably under the control of a division storekeeper, it is questionable just how far the accounting department should go in the investigation of shortages and overages. But in the reconciliation of inventories we believe a tolerance equivalent to 1 per cent of the book value of the respective stores account affected should be considered within reasonable bounds of satisfactory operation.

*Question*—Method of marking-down appliances, for resale to customers, as they revert into stock.

*Answer*—We believe that this is a matter where we must rely upon the good judgment of the local managers or agent in co-operation with the storekeeper.

Adverse circumstances are, in the majority of cases, the reason for the return of merchandise. Some customers are more considerate than others, when it comes to the use and application of merchandise. Accordingly, merchandise returned by one customer will have all the appearance of having been handled and treated with care, while the same class or type of merchandise returned by another customer will indicate hard usage. Accordingly, we believe the carrying cost to stores of merchandise returned should be in close proximity to such amount as it is determined the item can be offered for resale. This amount should be so set up that it will warrant an immediate purchase on the part of the customer.

*Question*—Accounting for merchandise on display.

*Answer*—There is only one system that we can recommend in this instance and that is the adoption of a suitable form, wherey all items of merchandise on display can and will be listed, then checked and so receipted for by the head of the particular sales group in charge.

As items are sold, requisitions should in turn be issued on the storekeeper by the head of the sales group for a like quantity of items for replenishing the display stock, and through the medium of this procedure the display stock should remain more or less constant.

When new or improved models of merchandise appear replacing older types, a new listing should be made, checked and receipted; this revised list should bear notation to the effect that it cancels all previous issues as of date.

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## *Public Utility Salvage Methods**

By HARRY ANDERSON

HARDWARE line material, such as crossarms, braces, bolts, brackets and pins, if they can be reconditioned, should be taken back into stock at full value. Bolts frequently have the threads slightly burred and can be reconditioned by having a nut or a die run over them. Regalvanizing of bolts or crossarm braces is not recommended, unless both costs and workmanship make it desirable. All hardware that is discolored by the weather should be cleaned by immersion in some satisfactory solution before being reissued. This will not add to its future life, but will improve its appearance and should be adopted as part of the salvage policy.

*Insulators*—

Insulators, in most cases, are chipped and burned. Therefore, they should not be considered as having any salvage value.

### Poles

It is difficult to find a market for wooden poles. The disposition, therefore, is a real problem. They must be picked up from the streets and highways where they are removed. If they are of any value, such as can be used for stubs or anchors, they should be graded and cut up into suitable lengths and taken into stock at quarter to half value of the original cost of the pole. Often it is possible to use some of these poles as skidders for the pole yard. Poles having no value should be given away for firewood rather than adding transportation expense by returning them to the pole yard. Often, especially on the highways, farmers are glad to get the poles and haul them away.

### Wire

Scrap guy wire has no value even as junk, except that sometimes small scrap of right lengths can be used for tailings. Scrap weatherproof wire, being a valuable salvage item, must be considered from many angles as to how it should be taken into stock at salvage or junk value. There are several rules and policies governing this procedure.

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* A report of the purchasing and storeroom committee, Accounting Section.

Removing insulation is done by burning it either in the open or furnace, by modern machinery, or by allowing a certain percentage deduction for insulation.

Copper from lead covered cables will take the highest grading. It is suggested in smaller properties, where they have no facilities to take care of the separation of lead from copper, that a guide book be followed showing the analysis of contents in all grades of cable. As is often the case, the smaller properties do not handle large enough quantities of salvage cable to justify the buying of equipment for separating the copper from the other metal.

### Pipe and Fittings

All iron pipe and scrap pipe should be brought into the salvage department for inspection. It is often possible, where pipe machines are available, that pipe can be cut to standard lengths and be re-threaded; also nipples can be made from the smaller pieces. This has to be governed by market conditions, as in some cases it is a question whether one could compete with modern machinery.

Water fittings are usually reclaimable. Small valves can be reconditioned by reseating and putting in new disks and by giving a good bath in some good cleaning compound to remove all foreign substance. They should then be given a thorough test before reissuing for service. Used fittings sometimes can be used, but care must be taken not to reissue them for new work, as this would lower the standard of the job.

*Obsolescence—*

Often it is the case that equipment is removed from service because of obsolescence or inadequacy. However, if certain work were done on it, there would still be certain service left in it for the right purposes.

In order to avoid losses due to obsolescence, the storekeeper must be cautioned about taking into stock leftover construction material, which later may have to be charged off as worthless.

*Set-Up for Salvage Operations—*

Utilities operating over large territories cannot afford to establish a salvage department, resulting in having a salvage engineer, but could have a handy man to sort over the returned material from various parts of the system, repair and return to the storeroom items which have been repaired. Opportunities for savings in this line are proportionately as large in the small utility as in the large utilities.

After all salvage material and equipment has been placed in the stores, the valuation should be governed by a person of authority in the construction and maintenance department, together with the general store keeper, and prices should be governed by market conditions. The salvage man and engineer of the construction and maintenance department should be thoroughly in accord as to reclaimed material.

It is to be remembered that the general store keeper or salvage man, as the case may be, should be careful not to allow inferior material to get back on the line in an attempt to make a showing, and the engineer of construction and maintenance department should be reasonable in accepting material for future use.

Boxes and containers should be provided in which to store scrap material and scrap wire. Old and nonreturnable oil drums usually make good containers. If the containers are not suitable and large enough to care for certain scrap materials, which are too large, a place should be provided to care for such scrap until time of disposal.

After all scrap material and scrap wire and cable have been sorted and graded, preparatory to selling, and where properties have no mechanical separation, and conditions do not permit the burning of insulation, it is current practice to allow a certain percentage of deduction for insulation on weatherproof wire.

Ferrous scrap in most cases can be sold in mixed lots. Where hardware has become obsolete, but is in good condition, it is a good policy to provide storage facilities in a suitable place for such material, noting on the boxes or racks that the material is "Not in Stock." The foremen of construction or maintenance crews, being familiar with this material, often are able to fill a requirement for some particular job, when nothing suitable is available from stock.

Scrap wire must be watched closely so as not to allow too great an accumulation, and the storekeeper must place himself in a position to take advantage of the best market conditions. Scrap material of no value should be taken to the dumping grounds after a certain amount of accumulation. This is to prevent taking up too much of the space provided for scrap material.

In preparing scrap material for sale, it must be remembered that you are matching your labor and skill against that of the junk man.

Where utilities are operating over large territories, it is not practicable to list items of junk under some classification and send them out for bids. In this case, bargaining with junk dealers is the only solution for disposing of junk wire and scrap material.

Where large properties are centralized and scrap material can be brought to a reclamation plant without any great transportation expense, such a plant should be a profitable department. If the utility is operating over a scattered territory, a reclamation plant would not seem profitable, as the hauling and transportation expense would be too great to realize a profit. In many cases in widely scattered properties the scrap wire and scrap material is disposed of at the local properties to save transportation expense. This should be entirely under the supervision of the local manager in charge of the property, providing they have no storekeeper.

Then there is to be considered the clerical and physical cost, as this feature might easily defeat the purpose of the salvage department, which, without the proper accounting system, would find it difficult to keep each lot of scrap material separate from other lots throughout the salvage operation, and so determine the exact return to be credited to each job.

*Co-operation of Field Men Necessary—*

One of the first points which will come to the mind of a salvage man or supervisor of stores is to wonder whether he is receiving all the material that he should receive from the various jobs and whether the field conditions in connection with this work are what they should be, as he has the choice of dealing with only what is turned over to him, or, on the other hand, of adopting an aggressive policy leading back to the source of material. Although material may not be wilfully wasted, many chances to practice economies through salvage methods are ruined through lack of education. Through contact with field men of the various departments, they could be educated to use up material with less waste and to salvage material which was formerly wasted entirely. This work could be done without lowering any standards of construction or unnecessarily increasing expense to the various departments.

*Removing Material from Service—*

In retiring material and equipment from service, a removal estimate is made up in the construction engi-

neering department, listing all material and equipment that is to be retired from service from data furnished by the field engineer. The foreman in charge of this retirement should be furnished with a suitable form on which should be listed all material removed from service on this retirement job. This form should be given to the storekeeper when the material is returned to the stores, and should then be checked with the removal estimate to assure that all material listed on the removal estimate has actually been removed from service and returned to stores.

In the event that the foreman's field records of actual removal necessitate a change, all copies of the removal estimate should be corrected, as it is presumed that the construction department's copy, signed by the foreman and the head of the department, is the basis of the accounting department charge to the reserve for depreciation.

After all material has been checked and graded and placed in the stores, and the scrap material put in the containers provided for the purpose, a valuation should then be placed on this returned material, the value being governed by market conditions, or the utility's policy in regard to the stores value of salvage material. The foreman's field slips, which are all numbered, should then be returned to the engineering department for final checking with removal estimate.

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## *Storage of Supplies, Storeroom Accounting and Disposal of Obsolete Supplies and Scrap**

By J. S. RUPPE

THE public utility or production companies operating in the different fields of electric light and power, city and interurban railways, automobile stages, gas, water, telephone, etc., spend large sums of money each year to purchase the various classes of materials and supplies that are needed to carry on their construction and rebuilding programs and for making repairs and improvements to their system.

Aside from such quantities of regular material and supplies bought for new construction or other specific jobs that have been planned and included in the yearly budget, they must also carry a large stock of extra material and equipment, such as spare parts for maintenance purposes, to make quick repairs or replacements of damaged or broken parts in any department of their plant, machinery or structures.

This maintenance or emergency stock, as it may be called, runs into a heavy investment, especially with those companies that are far from the manufacturing and distributing centers where supplies must be bought, yet because such stock is insurance against costly shutdowns that would seriously affect service, it is considered to be of such importance that the investment is worth while and justified. Many such supplies carried in the storerooms year after year are either very slow moving or entirely inactive, and are the most likely to become obsolete because of later and improved types appearing on the market.

### Storeroom

All public service companies own ond operate storerooms or warehouses for the safe and convenient storage of their supplies, where they can be carefully arranged in groups and sections in such a way as to be easily located and economically handled when brought in or taken out, and to be kept generally in such condition that the quantities on hand can be quickly determined when making periodical checks. These storerooms and warehouses are usually under the supervision of a capable man, experienced in the care, handling and storeroom accounting for supplies, who can organize the necessary force and conduct the stores or supply department in the most satisfactory and economical way for the benefit of all departments.

### Storekeeper

Different titles are given to the man in charge of the stores or supply department, such as storekeeper, district storekeeper, general storekeeper and supply agent, depending on the location and value of the stocks under his charge and whether he reports to an executive officer, manager, treasurer or department head. In any case, the worth of the man in charge of supplies depends, first, on his fitness for the position and his knowledge of the work to be done.

He should co-operate closely with all departments using material, and they should co-operate with him for determining the best ways and means of keeping the stocks active and at reasonable values. But there are times when the supply man is unable to get things done that he knows are for the best interests of the company, and at such times he should have the full support and firm backing of his superiors. The storekeeper should be the head of the supply department and have entire charge of all material and equipment owned by the company but not actually in service. He will be responsible for their inspection, receipt and custody, and make strict accounting of their movement.

### Ordering

The storekeeper should keep on hand at all times a sufficient stock of the different classes of standard material to meet the regular needs of all departments and from time to time should make requisitions on the purchasing agent for such quantities as may be necessary to maintain the amounts required.

All departments should place their orders on the storekeeper for any material or equipment that is to be charged to supplies and held in the storerooms or storage yards for future use, except fuel. All invoices, shipping receipts, bills of lading, freight, express or other papers that pertain to the storekeeper's orders for supplies, should be forwarded to him for making up unit costs, checking, approving and taking into account on his record.

Materials and equipment classed as standard, are those which have been recommended and approved by the superintendents and engineers of the different departments and are kept on hand by the storekeeper, until advised to change.

In order that the storekeeper may carry on his work successfully, it is essential that all departments anticipate their wants in advance for any unusual or large quantities of material, over what is regularly kept on hand, and advise him promptly so that he can arrange to have it when wanted. It is also important that they keep him informed of any proposed changes that are to be made in material by going from one standard to another, and of any improved patterns or later designs coming on the market, so the old lots on hand can be used up or disposed of before buying the new style.

* A report of the purchasing and storeroom committee.

### Stores Records

Different systems are used for keeping a record of all supplies bought, issued out, transferred or sold, also their cost and balance on hand. Such records are generally carried on a card or loose-leaf sheet drawn up for this purpose.

The supply record carried in the storeroom, to be complete should show the storekeeper and purchasing agents' order number and date of issue, the quantity ordered and received, the total of the invoice and the unit cost, the quantities issued out or returned to supplies and the requisition number, the balance on hand, and the name of the firm filling the order.

Invoices for supplies, after serving the purpose of the storekeeper, are forwarded to the accounting or treasury department to be paid.

### Issuing

All supplies in the storerooms, are issued on regular forms of requisition known as an issue from stock, which are made out by the workman and approved by the foreman before being turned over to the stock clerk to furnish the material.

After a stock slip has been filled, it is signed by the stores clerk and turned into the office to be priced, extended, checked and posted to the stock record cards, and then forwarded to the accounting department, where proper charge and credit is made to the accounts affected.

### Obsolete Stock

The set-up or organization of any company would determine what department or departments were responsible for keeping the supplies in a clean and active condition, and for making prompt disposal of any surplus quantities on hand, or of any undesirable or obsolete stock that had accumulated at any point on the system.

Supplies may be divided into different classes as follows: (1) active, (2) slow moving, (3) inactive, but serviceable when needed, (4) totally inactive and obsolete. The men in charge of the supply department will know from their close contact with the material and from the stock records in the storerooms, just what items and pieces belong in the different classes and should know the reason and purpose for holding them.

At different times during the year, the storekeeper should make up lists of such materials and equipment, which show no movement month after month or year after year, and should notify the department for whose use they were bought, for recommendation and reasons to hold for future use or for approval to dispose of as being no longer needed. Upon proper approval of a department that certain material in supplies, either new or in used condition, shall be disposed of, it may be transferred to an obsolete supply account at its present storeroom cost, and moved to a separate section of the warehouse to be sold as is, or scrapped.

Detail lists of obsolete stock on hand should be made up by the storekeeper and forwarded to the company's purchasing agent or other authorized person, to arrange for its sale at the best price offered, after which the supplies account will be cleared and adjusted accordingly. It is generally acknowledged that obsolete supplies are a false asset if carried on the company's books at their full or original cost, while their actual value at the time may only be their worth as scrap. Therefore, it is important to get rid of them as soon as their real condition is known.

It is customary and regular for all companies to take an inventory of their supplies, at regular intervals, at which time any materials that have shown no movement during the past year, may be classed as inactive and noted as such in a separate column on the inventory sheets, which can be totaled up to show the value of inactive supplies on hand.

Copies of these completed inventories should be sent to the managers, superintendents, engineers and department heads, so that they will know what supplies are being carried for the use of their departments and will advise the storekeeper of any items that are not serviceable and may be disposed of.

### Merchandise

For several years past, the light and power companies have been handling merchandise for sale to customers and to the general public. These goods are bought and stored the same as other supplies, except that they are kept in separate inclosures in the warehouses where they can be properly protected, and may be accounted for on a separate form of cash or charge sale slip when sold or returned to the storeroom by customers.

These merchandise stocks require greater care and protection than other less valuable and bulky material, to prevent losses from theft in the warehouses and salesrooms and from being shop worn and damaged when transferred from one place to another for demonstration and display. The constant changes in design and the improvements that are being made on all electrical appliances, mean that careful consideration must be given to their purchase at all times to avoid overstocking certain items that may in a short time become old type articles and hard to move.

Another feature of the merchandising business that must be watched closely, is the number of used or second-hand appliances returned to the company's storerooms for various reasons, such as for non-payment or because taken in on the sale of new equipment. All such used appliances should be carefully examined when brought into the company's storerooms and either put in working condition to be sold again or scrapped outright at the time. Merchandise that has been in service and is returned to the storerooms to be taken into supplies, will be appraised by the department authorized to fix the price, which should be at its probable sales value, regardless of the allowance that was made to the customer turning it in.

By keeping these old-type and used appliances moving, their accumulating in the warehouses or salesroom is prevented, thus allowing more space for the storage of new goods and keeping down the investment in this class of supplies.

### Purchasing

While the purchasing agent may report to a different head, and his department be organized separate from that of the stores or supply department, the workings of both departments are tied together in such a way that there must be the utmost harmony and close contact between them, to carry on their work in a satisfactory way and produce the results that are expected from their employers.

On the purchasing agent depends what prices the company will pay for its supplies and when delivery will be made. He should arrange for the return or exchange where the wrong materials were shipped; he should have an overcharge corrected, and credit issued; he should sell all scrap and obsolete materials; he should arrange for the return and secure credit for reels, oil drums or other containers returned to the

shipper; he should advise the storekeeper of changing market conditions when supplies can be bought at the lowest price; and, generally, he should assist and advise those interested in materials.

The upkeep and reduction of supplies to a great extent depends on the purchasing agent's knowledge of the various markets where they can be procured, and the time it will take to deliver them to his company. With these facts known and understood, there would be no real or justifiable reason for the storekeeper to order in large quantities that would amount to an overstock, nor would he be afraid to let his supplies run down to minimum quantities before ordering more, because of the assurance that he would have them on hand when wanted.

In every purchase of supplies required for regular stock and in emergencies, also in the sale of obsolete and scrap materials sold outside of the company, the purchasing agent and storekeeper are concerned and must stand together in the performance of their work. They should consult freely with each other, and with all departments using materials, as to the best plans and ways of handling, storing and accounting for them, in order to reduce, as far as possible, the number of forms and sizes of standard materials to a practical minimum.

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# *Executive Instructions to Purchasing & Stores Departments**

By J. M. LAFLIN

RELATIVE to the publication of executive instructions on the duties of purchasing and stores departments in the company organization, there is little doubt that this would prove to be of inestimable value. Not only would it serve to standardize methods of procedure in the performance of routine duties, but it would also eliminate, to a great extent, the confusion incident to changes in personnel. There instructions should include rules of procedure, proper method of handling and accounting for major and minor spare parts, and storeroom regulations.

### Detailed Instructions Are Advisable

The instructions should not be confined to generalities or to a brief summary of the duties of the respective departments, but instead, should outline in complete detail the proper methods of performing, step by step, the various duties involved. In addition to this, there should be included a definite, fixed schedule for the performance of the different duties, in order to insure the recording each day of all transactions executed the previous day.

### Merchandise Stock

Of first importance would be the issuance of requisitions by the stores ledger clerk, covering materials and supplies on orders representing sales to customers. Serial number of the order covering the sale should be shown on the stores requisition and the requisition number noted in the space provided on the sales order as cross reference. This should be the first duty of the stores ledger clerk each morning and, immediately after completion, the sales orders should be forwarded to the accounting department for posting to customers' accounts.

By strict adherence to such a schedule, the purchases of customers on any given day would be posted to their respective accounts before noon of the following day. This would minimize the chances of an account being closed without including a merchandise sale of which the bookkeeper had no knowledge.

### Inactive Stock

Applicable to a company with several branch stores and a central purchasing department, the executive instructions should contain rules outlining the procedure relative to materials and supplies that have been carried on the books indefinitely, with no prospect of using or disposing of them.

By supplying the purchasing department with a list of such materials and supplies, including quantities, prices as shown and a complete description, it is frequently possible to effect a transfer to another branch where such items can be used or disposed of.

### Arrangement in Stores Ledger

The instructions should also outline in detail the proper arrangement of the materials and supplies carried in the stores ledgers. Usually there are several groups or divisions, such as merchandise, line material, meters and transformers, etc. The supplies under each group or division should be arranged in alphabetical sequence with standardized names and complete descriptions.

Due to lack of definite instructions concerning proper arrangement, stores ledger clerks frequently inaugurate a system of their own, insofar as minor details are concerned, with the result that there is total lack of uniformity. For example, one stores ledger clerk will list waffle irons under letter "W" and another as "Irons, Waffle," under the letter "I." One will carry spare parts of appliances immediately following the respective appliances, while another will carry parts for all appliances in a separate section, alphabetically arranged.

### Inventory Certain Stock Monthly

The instructions should also require a monthly inventory of lamps, appliances, and major spare parts of resale material and poles, meters and transformers. Any discrepancies that may arise can be easily located through checking the transactions for the previous month, or as sometimes occurs, by recalling the sale or usage of material for which no orders had been issued.

### Arrangement of Stock

Definite rules should also be included covering the duties of storeroom foreman or stockclerks relative to the proper arrangement of materials. The annual inventory can be greatly simplified and facilitated through the proper arrangement of materials, and to effect this, bins and pigeon holes should be provided.

Bolts, of which many different kinds and sizes are always carried, should be arranged in layers in pigeon holes, a definite number in each layer, with narrow strips of cardboard, cut from carton boxes, between each layer. Washers should be arranged in stacks, a given number in each stack, so that, when taking inventory, instead of counting innumerable bolts and washers, the quantity on hand is easily obtained by multiplying the number in each layer or stack by the numbers of full layers or stacks and adding whatever may be in a broken layer or stack.

The publication of executive instructions on the duties of purchasing and stores departments in the company organization should include complete information

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* A report of the purchasing and storeroom committee, Accounting Section.

relative to the proper accounting methods, rules of procedure, arrangement of the different items carried in the ledger and arrangement of all materials and supplies.

### Spare Part Accounting

The cost of accounting for minor spare parts is out of all proportion to the results obtained. At one branch of a northwestern utility company, the spare parts division of stores ledgers contain more than 500 separate accounts, the great majority of which represent items costing but a few cents each. Every month these items are laboriously taped on the adding machine in obtaining a balance of stock on hand. Were mercantile establishments to endeavor to keep a record of their purchases and issues on each item carried in stock, the expense would either bankrupt them or force a drastic increase in selling price.

I can see no reason why it would not be advantageous to charge all minor spare parts, most of which are used in replacements, direct to operation when received, and thereby save considerable accounting expense.

In my opinion, neither major nor minor spare parts should be included when a turnover of material is figured. All spare parts are carried, it might be said, for the convenience of our customers and, at the time of their purchase, there is no reason to believe they will be used or sold within any definite period.

# STATISTICS*

THE work of the statistics committee this year has consisted of gathering information concerning the electric utility for the N.E.L.A., in co-operation with the chairman of the national statistics committee.

### Municipal Systems Reporting

The first work of the committee consisted of obtaining data regarding communities being served by municipal plants. The committee has obtained the co-operation of municipally owned plants in Seattle and Tacoma, Wash., Eugene, McMinnville, and Milton, Ore., and the managers of these plants are now making monthly statistical reports to national headquarters. This co-operation of the managers of these municipally owned utilities, looking toward the production of more complete data on the light and power business from this territory, is much appreciated.

### Discrepancies in Reporting

The monthly statistical report made to the N.E.L.A., divides small light and power from large light and power at a demand of 50 kw., but not all of the reporting utilities are following this classification. Some companies are reporting small light and power retail in the commercial group, and industrial sales under the heading "Large Light and Power Wholesale." Another company is making the dividing line at 40 kw. Still another does not segregate between large light and power and small light and power, but reports all power under one classification. Some companies are making reports in close conformity with the national committee's instructions.This lack of co-ordination makes the statistical reports of N.E.L.A., which are published monthly, somewhat misleading, but the executives of the companies are not willing to spend more money at this time in making further segregations, and it will be necessary for us to put up with the situation as it is now.

Your committee has been asked by the N.E.L.A. to compile a list showing the electric light and power utility serving each community in this territory, which covers the states of Washington, Oregon, Idaho, Utah, and Montana. Your committee has no member in Montana, nor in Utah, but will attempt to obtain the information at an early date. The statistical department at N.E.L.A. headquarters is not sure that the present list is correct, and desires that the list be checked by persons who are sure of the name of the utility serving the community.

### Uniform Tax Data Valuable

The member companies of this association, especially those operating in Oregon and Washington, have made more or less use of the tax-earnings ratio comparison and heretofore each company has assembled its own figures in its own way. As is necessarily true of any situation which is more or less complex, the methods used are not uniform and the results obtained and the statements based on those results may differ widely, even to the extent of nullifying the beneficial effect expected from their use. This practice, if it were consistently followed by each member company, would mean that each would have to write and answer as many letters, minus one, as there are companies in the district, while if the statistics committee was charged with the duty of assembling these data and submitting a complete summation to each member company, the results obtained would be uniformly beneficial to all members.

It is therefore suggested that hereafter the statistics committee be charged with the duty of collecting this information from the member companies as soon after the first of each year as the information is available. The committee should then assemble the information thus obtained into a tabular report and submit a copy to each member company, together with such notes, comments or other pertinent information as may be necessary.

It is obvious that if the reports of the member companies are to be comparable, one with another, they will have to be in the form of answers to a questionnaire submitted by the committee. Considerable thought must be given to the preparation of this questionnaire, giving due consideration to the different methods of accounting by different companies and to the human equation which enters in largely where the matter of judgment is a factor.

If the statistics committee can secure the co-operation of the Pacific Coast Electrical Association in securing similar reports for the California utilities, the benefits will be greatly enhanced.

The work of our committee has been, in the past, largely devoted to theory and to some extent, to research, mostly for the benefit of the national association from which we of the Northwest association benefit indirectly. It seems that herein we have an opportunity to prove our worth as a committee in the Northwest association and render a distinct service direct to the members of our own geographic division.

One of the member companies recently had a state-

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* Report of the statistics committee, Accounting Section. E. W. Moreland, Pacific Northwest Public Service Company, chairman. L. J. Pierce, Puget Sound Power & Light Company, vice-chairman.
Idaho Power Company: E. F. Roehrig.
Mountain States Power Company: F. C. Hart.
Pacific Power & Electric Company: L. N. Barnhart.
Portland General Electric Company: H. G. Harvey.

ment of costs before a regulatory body. The costs appeared to be excessively large to the members of the regulatory body, but when they learned of higher costs experienced for the same work in the same territory by another public service corporation, all doubt was removed from their minds and the utility whose costs were under review obtained approval of these costs.

### Committee Organization

Your committee recommends that in the future the statistics committee should be made up of one employee of each of the major companies operating in the territory covered by the association, the members to be selected by executives of the utilities in order that the employee may give the necessary time and energy toward getting information which may be requested by either the national association or the Northwest association or by member companies. Acceptance of a place on a committee implies that the committeeman will give the time and put forth the energy necessary to make the work of the committee a success; and once having been selected, the members of the committee should be continued indefinitely. The chairman of the committee should be rotated through the committee personnel.

# Commercial Section Reports*

## *Introductory Statement*

By GEORGE E. SULLIVAN, Chairman

THE work of twelve committees of the Commercial Section functioning under the three bureaus, and of three committees functioning outside the bureaus was brought to a climax at the section's midyear meeting at Spokane, March 16 and 17, 1931. All committees reported at this meeting, a resume of which appeared in the April 1 issue of Electrical West. These fifteen reports, covering every phase of commercial activity, are printed in full in the following pages.

* Executive Committee: George E. Sullivan, chairman; R. U. Muffley, vice-chairman; L. V. Ross, L. W. Brainard, T. M. Gibbes.

# LIGHTING BUREAU[1]

## *Industrial Lighting**

PRIOR to this year the commercial and industrial divisions of the lighting bureau have functioned under the same committee head. It was recommended by last year's committee that these two divisions be handled by separate committees in order to broaden the work. "The general activities of these departments are of course similar," the report states, "but definite workable plans for the one may not be at all practicable for the other. The industrial lighting activities call for a greater difference in their set-up than do the activities of the other departments; therefore, an industrial committee is imperative for the best results."

It is the purpose of this report to discuss the potential market and to outline a general sales promotional program which may be varied to suit local conditions existing in any community or district throughout the northwest territory.

### The Market

Before any market can be exploited effectively its extent must be known more or less comprehensively. The market for good industrial lighting is large in scope and prospect lists may be compiled in every community, large or small. The prospects may be divided into two classifications:

1. Notably large establishments, such as manufacturing plants employing electrical maintenance departments and purchasing equipment direct from manufacturers or wholesalers, and

2. The smaller industrials or semi-industrials, such as laundries, dry cleaning establishments, bakeries, wood-working and machine shops, garages, etc., who are dependent upon electrical contractors for the installation and maintenance of equipment.

Under both classifications will be found many buildings of modern design, some of which embody the best known standards of illumination, while some of the older buildings have been relighted in recent years. There still remain, however, many industrial structures whose lighting facilities have been left almost untouched since the time of their construction. In these buildings lighting has been looked upon as a part of the building service, along with the heating and ventilating, and has been regarded as a necessary item of overhead expense to be kept as low as consistent with a reasonable degree of comfort. However, when it is considered that "light is a tool for seeing" and seeing enters into every physical and mental act in the productive process, it is evident that lighting should rather be classed with productive equipment than with service equipment. Its proper design and maintenance should be a concern of the production manager equally with that of machines, motors, tools, etc. A lighting system designed ten years ago is as much a handicap to modern production as a 1920 model motor truck would be to the haulage of materials to or from the plant.

The importance of allocating the lighting with the productive equipment is evident when the relative cost of labor and light is considered. A study of particular cases shows a wide variation in this relation, but in most cases the difference between the outlay for good and for poor illumination would be equal to the cost of only a few minutes per day of the worker's time.

Facts have been accumulated which prove beyond a doubt that good lighting increases production, eliminates waste and spoilage, saves time, prevents accidents and fosters improved morale—all of which means lower unit costs and greater profit. Much of this material has been published by the electrical industry and made available in forms suitable for distribution to factory owners and managers. The dissemination of this sort of data is a long step toward influencing the attitude of industrial executives in this respect. The work must go on until lighting takes its proper place in factory accounting.

[1] L. V. Ross, The Washington Water Power Company, chairman. L. B. Gawan, Utah Power & Light Company, vice-chairman.

* Report of the industrial lighting committee, lighting bureau, Commercial Section. L. B. Gawan, Utah Power & Light Company, chairman.
Benjamin Electric & Manufacturing Company: Raymond Ackerman.
General Electric Supply Company: Elmer Jonsson.
Westinghouse Lamp Company: E. A. Evans.

An example set by one progressive factory soon has its influence upon other industrials in that territory. Workmen and executives alike are quick to appreciate the advantages and the word is soon passed along to other plants, and, too, once sold better lighting, the user continues to be a prospect for a still further improved system. Each time we take a step upward in values we think we have arrived at the limit, but almost invariably advantages have been found that soon show the need for still higher intensities and the work goes on.

As one looks back over the developments of the past few years the truth of the foregoing statement is emphasized. Following the world war we heard of a few notable cases where general illumination of 10 to 12 footcandles had replaced systems of from 1 to 3 footcandles. Later there came in greater numbers installations of 20, 35 and 50 footcandles. A more recent development has been the reinforcing of the general illumination of these values with localized lighting, supplied by intensifiers of various types at points where close eye-work is performed. At these points values running into several hundred footcandles are sometimes employed.

We are given notice of still more radical developments. Many of the more forward-looking leaders of the lighting industry are predicting that we will soon be required to revolutionize the whole scheme of lighting for work areas. These conclusions are based on investigations indicating that present day standards are providing only 10 to 15 per cent as much artificial light as should be used if the eyes are to function accurately, speedily, and, with certain qualifications, tirelessly. If we are to raise intensities much higher without introducing glare, fixtures must be developed with large luminous surfaces instead of the concentrating reflectors used at present.

Already systems of this character have found their way into hospital operating rooms, where 1,400 footcandles of shadowless, glareless illumination is produced by luminous ceilings fitted with multiple prismatic control lenses. There are many industrial processes requiring a precision comparable with that of the operating surgeon, and where the cost of such a lighting system would be justifiable.

Recently developed automatic lighting control devices will find their first application in industrial plants and will do much to increase the load factor. By the use of a relay embodying a photo-electric cell which is highly sensitive to variations of light, it is possible and practicable to control the lighting installation, so that as the intensity of illumination falls to a certain point, the lights are automatically turned on.

The field for industrial lighting is by no means limited to the application of light to factories. Mines, mills, railway yards and structures, docks, storage yards and warehouses, should be included. Each classification is deserving of special consideration, both as to sales approach and engineering practice.

### Ultra-Violet Light

A very noteworthy progress has been made during the past year in the field of lamps which produce ultra-violet radiation. There is much speculation at the present time as to what applications these lamps will find in industry, both as an aid to industrial processes directly and for the health maintenance of workmen. Most of these developments are more or less in the laboratory stage and we should be able to appraise their value more accurately in the near future. There is, however, one development in this field which seems to spell opportunity for immediate sales. Tungsten filament lamps in ultra-violet transmitting bulbs are apt to have a wide field of application in the poultry industry. Tests already conducted by the poultry departments of several leading universities and by some commercial poultry raisers, have proved definitely that the use of these lamps will enable the raising of strong, healthy chicks indoors, without sunlight, cod liver oil, or other means of preventing rickets. When used in brooders, 60-watt lamps of this character will provide the heat, light and ultra-violet radiation necessary.

The use of these lamps in other tests has proved them to be of material aid to increased egg production and also to improving the quality of the eggs. ("Ultra-Violet Boon to Poultry Industry," The Magazine of Light, January, 1931.)

### Protective Lighting

Another important field not to be overlooked is that of lighting for the protection of industrial property such as storage yards, buildings, etc. Floodlighting of such property in many cases may serve the dual purpose of facilitating the detection of marauders and of advertising the institution.

Two special kinds of lighting should be added to the regular illumination of every factory. Emergency lights should be so installed that the accidental cutting off of the supply from the usual lighting circuits will not be likely to extinguish them. Night lights giving adequate illumination for protection should be provided in all large rooms and for all stairs and passageways.

### Color Discrimination

There are many industrial processes which require an artifical daylight of constant quality for the accurate discrimination of color. This is a profitable field for the lighting salesman, which investigation shows has been scarcely exploited. The load to be obtained is particularly attractive because of the high absorption of color-correction filters. Often these processes are of major importance, as inability properly to match or discern colors in a certain department may be the cause of much spoiled material or may slow up operations throughout the entire plant. Such processes will be found in cigar factories, color factories, paint shops, textile mills, garment factories, color printing, work with alloys, ore refineries, chemical laboratories, paper-mills, flour-mills, sugar refineries, furniture manufacture, and laundries. Sometimes the proper treatment of lighting for color correction in an individual department will serve as the entering wedge for relighting the entire plant.

Likewise a good installation of lighting in the drafting room of an industrial establishment will go far toward pointing out to the engineering staff the advantages of proper illumination for other work areas in the plant. Usually the wattage required per square foot of floor space is as high as that needed for any class of fine work, so that the salesman is well repaid for his initial effort.

A survey of the general office lighting may serve in the same manner as the point of entree.

### Schools

A survey of workrooms in schools and colleges, such as the mechanic arts departments, shops, laboratories and drafting rooms, shows the need for improved lighting. The students of today will be the industrial executives of tomorrow and, therefore, concerted effort should be put forth to see that they are acquainted with the economics of good lighting.

### Local Campaigns

Investigations made by the committee have brought out the fact that nearly all of the member companies

are now conducting commercial and industrial lighting activities, and that some very successful industrial lighting campaigns have been sponsored in certain localities. However, throughout most of the territory, industrial lighting sales have lagged considerably behind those of the commercial field. In the opinion of the committee this condition is largely due to the very fact that the promotional work directed toward selling commercial lighting has generally met with more ready acceptance, and also because of a lack of concentrated effort to contact the smaller industrials.

The facts at hand point very clearly to the need for more strenuous effort along educational lines. Realizing the need for pre-selling or educational campaigns, the lighting committee of The Society for Electrical Development has prepared a sales promotion manual for a local market development program, and is sponsoring a direct-by-mail series of letters and booklets adaptable to local campaigns to be handled by leagues or other co-operative groups. Where local associations are functioning, the committee recommends that this, or some similar form of campaign, be sponsored and that further steps be taken to effect a working arrangement for a direct sales campaign to follow.

In most communities statistics indicate that seven out of ten factories still need better lighting, but first they need to be convinced what adequate lighting is and what it will do for them. The combined effort of all interests engaged in the lighting business, including the equipment manufacturers, wholesalers, lamp companies, contractors and power companies, is necessary to further a general educational program and to secure the attention of industrial executives.

Several of the larger equipment manufacturers have already sponsored direct-mail campaigns reaching the managers and engineers of the larger industrials throughout this territory. However, the field is so large that the manufacturer usually does not maintain a sales force of sufficient size to follow-up properly all of these prospects, and as yet most of the smaller industrials have not received this literature. The manufacturer is, to a considerable extent, dependent upon his jobbers' salesmen to deliver his message. The jobber's representative contacting the industrials is seldom a lighting specialist and has not the time at his disposal thoroughly to analyze the specific lighting problems of each customer. In the case of the very small industrial the sales contact is largely left to the electrical contractor. It seems to the committee that the key to this situation lies in the hands of the power company. Specialized lighting service should be placed at the disposal of the contractor, the manufacturer, and the jobber's representative, as well as the customer, in such a manner that it will be utilized to the fullest extent and with complete confidence. These four agencies must join hands in an aggressive campaign, if the full possibilities of the market are to be realized. The salesman of an equipment house usually has a wide territory to cover and each lighting sale requires considerable time for the study of conditions on the premises. The power company's lighting service man is so situated that he can "live with the job" until the sale is completed. It is apparent also that his company serves the customer in a continuing relationship after the sale is made and for this reason he is in a position further to inspire customer confidence.

(The discussion of methods of organizing a lighting service department and of the training of personnel, is purposely omitted in this report because these subjects have been discussed in previous reports of the commercial and industrial lighting committee).

In undertaking a local campaign after the local market has been analyzed, obviously the next step is to set up a concrete, attainable sales objective, not merely as a mark to aim at, but as a scale by which to decide the amount of money, time and effort necessary to attain it. This objective may take the form of dollars in annual revenue to accrue from the sales effort, of additional kilowatts to be connected to the lines, or of attaining a set number of lighting surveys, or of relighting a specific number of existing installations. Keeping this objective before the department is the only way to attain the determined quota.

### Adequate Wiring

There can be no doubt that insufficient wiring capacity in industrial buildings is throttling the sale of improved lighting. The national commercial and industrial lighting committee, through a subcommittee on industrial wiring, is preparing specifications to cover minimum requirements for industrial buildings of various types. This, as it applies to new buildings, will be of material aid to the raising of lighting standards in the future. It is the opinion of the committee that the best method of procedure in the case of relighting old buildings, is to survey thoroughly the present wiring and to make recommendations for all new wiring necessary. In other words, the prospect will more readily accept the proposal of improved lighting if he understands from the beginning that wiring costs are involved.

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## *Commercial Lighting**

THIS year's presentation of the report of the commercial lighting committee of the lighting bureau, was in the nature of a display and exhibit of equipment and materials available for use by the lighting service departments of the various utilities of the section in selling the idea of better lighting to the customers on our lines. Sales prospectuses covering the several divisions of lighting have been prepared and are being prepared by the lamp works of the manufacturers, also by the manufacturers of lighting equipment. These portfolios and sales plans will not be considered in this report, but rather we will consider such equipment as can be used in presenting talks before groups, either luncheon clubs or meetings of interested parties.

In the past, reports of the lighting activities and of the results achieved by the various utilities, have been prepared and read before the convention. The major benefits of these reports have been enjoyed by those making up the reports.

We believe that central station executives are very much interested in knowing about better lighting requirements and possibilities, by reason of the additional revenues which come from better lighting loads. We believe that central station executives are just as much interested in the lighting story as are the business men and factory managers, who are vitally interested in the additional profits resulting therefrom in the way of increased production, bettered morale, and the lessening of spoilage.

For that reason, it was decided, rather than to read a report containing a lot of figures, to present in a condensed form the story of better lighting and its

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* Report of the commercial lighting committee, lighting bureau, Commercial Section. T. W. Fitch, Portland General Electric Company, chairman.
General Electric Lamp Works: W. E. Potter.
Northwestern Electric Company: M. S. Glenn.
Portland General Electric Company: L. D. Johnson, W. D. Williams.

utilization, so that we in the utility companies could appreciate what is being done for the customer, and how the customer is brought to want better lighting.

Our committee will present the subject of commercial lighting under four headings:

1. Education of the customer, through talks on "Light as an Aid to Vision," working up to the use of light as a sales aid in mercantile establishments, and as a raw material in industry, increasing profits by decreasing spoilage and costs.
2. Assistance to Customers, through the analysis of just what constitutes good lighting, and by calling to their attention the various elements to be watched for, with an evaluation of these several elements.
3. The need of using proper voltage lamps in order to obtain the utmost in lighting value for the amount of money spent.
4. The new dual-purpose lighting idea of combining light for vision and light for health.

### Education of Customer

The substance of the talk on "Light as an Aid to Vision," with charts for illustration, is as follows:

Here is shown the structure of the eye, and what is happening when we see, also what is happening when we try to see under deficient illumination. Inasmuch as we see by reflected light only, the object is brought closer to the eye in order to increase the intensity of light reflected to the retina. However, in bringing the object closer to the eye, we cause the eyes to turn in or cross slightly while obtaining a focus. The delicate side muscles of the eye are easily tired by this unaccustomed strain and eye strain is the result. Next is the glare experiment on the card, with which you are all no doubt acquainted. This small print about the opening is easily read when no bright light source is in the range of vision, but immediately we introduce a bright light source, our ability to see is very seriously impaired. This is because the iris of the eye, in endeavoring to protect the retina, closes up, limiting the amount of light admitted, with the result that sufficient light cannot get to the retina for us to see the object itself efficiently. The eye is working against itself and full value of the light provided cannot be obtained.

Third, is the experiment proving the ability to see and discern details better under higher lighting intensities. Since we only see by reflected light, the ease with which we see depends upon the quantity and quality of light which can be reflected by the object to our eye. The revolving object appears to slow down under the higher intensity, due to our being able to discern details more readily. It seems to us to be revolving more slowly because we can see more distinctly. Actually the speed in unchanged.

Fourth, the effect of colored light on the appearance of fabrics and color disks is shown. The primary colors of light are different from the primary colors of paint pigments because of the different reactions taking place. When goods are shown under light other than white light, the color values will change. Goods are returned as unsatisfactory and whatever profit was made on the original sale is lost in the exchange and additional time taken to satisfy the customer. Matching colors under daylight units enables us to obtain matches which hold good under outdoor conditions.

The story is then carried along so that the customer can visualize the suggested effects in his own store.

Another lecture with slides for illustration has been prepared by the Lamp Works of the General Electric Company, covering the different phases of lighting, commercial, industrial, residential and outdoor flood-lighting. A printed talk accompanies the slides and approximately one hour is required for the delivery. These slides and talks are available to the various companies, and programs can be put on before luncheon clubs or other groups by anyone, not necessarily a lighting specialist.

### Assistance to Customers

Some interesting points bearing on this subject were brought before the committee by Clark Baker of the National Lamp Works, Oakland, Calif. Mr. Baker had some very interesting slides of suggested store and building front rearrangements to permit high intensity window lighting, with provision made for adequate ventilation to overcome the additional heat from the lamps. The scheme also brings about a greatly improved appearance of the store front and for the entire block, as the remodeling is extended. One of the added benefits to the building owner is the rehabilitation of an older shopping area, resulting from traffic following good lighting. Rental values go up as traffic increases.

Mr. Baker also showed how colored light affects the appearance of fabrics, and colored articles, also that white light, while containing all colors, contains these colors in definite proportions, and that white light cannot be obtained synthetically by mixing equal quantities of red, green and purple light from separate sources.

The fixture rating chart was developed by the illuminating engineering department of the Portland General Electric Company, primarily as a guide for the School Board, to enable them to evaluate the various factors entering into good lighting. These factors are found to a varying degree in different types of lighting equipment and the weighted averages for each fixture, considering glare, light distribution, illumination efficiency, shadows, maintenance, fixture cost and general appearance, are determined and charted.

The fixture rating charts are the result of considerable study, and are quite accurate in their evaluations. This work has resulted in an even chance being accorded the various lighting units submitted to the board and has practically eliminated the effect of high pressure methods and politics. Authoritative data on the different bases have been insisted upon in all cases and the relationship and value of the various elements in relation to the total valuation has been clearly set forth. We believe that this is a contribution of considerable value, developed in our endeavor to be of assistance to our customers. While these charts were developed particularly for school jobs, they can be extended to different classes of lighting installations by varying the values placed upon the different factors. These charts have raised the standard of school lighting in Portland. Instead of direct lighting, as heretofore, the lighting installations in new schools and many of the old schools are now semi-indirect, and in some cases, totally indirect.

### Lamp Socket Voltage

The effect of a deviation in voltage at the lamp socket from the rated voltage of lamps, both on the quality and cost of the illumination and on the revenue of the central station, is illustrated by the animated voltage chart of the National Lamp Works. This shows how the relationship of socket voltage to lamp voltage rating affects the light output of the lamp, affects the current consumption, the revenue and the total cost of the light, taking into consideration the price of the lamp and the price of current.

### Dual-Purpose Lighting

Considerable recent study has been given the subject of dual-purpose lighting, or the development of lighting units to provide light for health as well as light for vision. The Mazda S-1 lamp has been used as a light source in several such combination fixtures and the results have been fairly satisfactory. However, considerable research is still necessary, but the route seems to be fairly clearly charted.

In Cleveland, Ohio, the office of Mr. Luckeisch at Nela Park, and the office of the president of the electric league, have been equipped with these dual-purpose units. They provide about 10 foot-candles of indirect light and approximately 100 foot-candles of downward light from the sun lamp itself. The rays from the sun lamp are reflected from aluminum baffles to eliminate the glare from the arc and the filament. With this combination fixture, 100 foot-candles on the desk was

not unpleasant and there was no feeling of too much light. Also a sufficient ultra-violet component was present to keep a person feeling fit.

The National Broadcasting Company at Chicago has installed ultra-violet equipment to irradiate members of a troupe while at work before the microphone. Since all the activity is indoors, and the health and vitality of the artists are of prime importance, the ultra-violet equipment is being tried out as a means of reproducing a sunshine effect, to see if it will benefit those confined to the studio for long hours.

The latest issue of "Lighting" contains an article by Mr. Luckeisch illustrating several possible designs of overhead dual-purpose units, also some portable floor-lamp models very closely resembling ordinary floor lamps. The ultra-violet output has been calibrated and the dosage time element determined for different distances away from the light source. In fact, there has been developed a new unit of measurement of the effectiveness of ultra-violet sources, namely, the MPE (minimum perceptible erythema), which means the first slight reddening of the skin.

Experiments have been made with fish growth under ultra-violet light. On poultry farms, experiments are being conducted to increase egg production and to better the quality of the bird itself. Dual-purpose lighting in homes, industries and on farms looks like a very promising new field of use for electricty.

Sun lamps are becoming a feature in miniature golf courses, swimming pools, squash courts, etc. Layouts of the sun lamps on the scale of a regular lighting layout are out of the question at present, owing to the cost of the units and wiring. Lamps placed at strategic locations, however, such as over the tees and greens of the golf courses, along the walls of swimming pool rooms, or along the borders of the outdoor pools, appears to be the best plan to date. Sun lamps in washrooms, children's playrooms, home libraries, etc. are becoming more general and while the sale of this equipment comes more directly under the merchandising departments, the lighting service departments are much interested and are involved because of the technical nature of the development.

This report is designed to give a little clearer conception of the work of the lighting service departments, and a better idea of what is being done with the customers to encourage the installation of better lighting. The work of these departments is rapidly becoming not merely that of lighting specialists, but of specialists in *seeing*.

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## *Home Lighting**

THIS report is illustrated by 22 cards, picturing tables, charts and pictures to bring out the size and value of the home lighting load. The texts of the cards are given in a supplement hereto. The Home Lighting Committee makes no claim to originality in this report, as the statistics and rough outline have been furnished us by a member of the domestic lighting committee of the N.E.L.A.

It is a well known fact that practically all utility executives agree that the two things they strive most for are improved consumer relations and increased revenue. Of these two, most emphasize the greater importance of consumer good will. This is affirmed by the many manifestations of good will building by utilities everywhere.

CARD 1.

It is widely known that extensive service departments are maintained to teach people how to cook, that highly developed radio programs are sponsored to give housewives the latest recipes. Considerable attention is given to the preservation of food and the use of the major, as well as of the smaller appliances. Housewives are taught how to launder the modern way and through labor-saving devices the idea of having more time to play is stressed. Every year millions of dollars are spent for these things and the expenditure is considered in the light of an investment and a service to the customer.

CARD 2.

But when it comes to spending money for teaching people how to use the one thing that pays the largest part of utilities' total revenue, very few central stations have an appropriation available to cover it.

How many executives appreciate that in *lighting* they have a contact with 100 per cent of the homes on their lines? How many realize the real responsibility they have in assisting their customers to use correctly the electric lamps in their respective homes?

CARD 3.

The lighting illustrated by this card shows why many complain of headaches after reading. The same poor lighting produces drowsiness and listlessness.

CARD 4.

Why is it that 30 per cent of the children graduating from school have defective vision? A large part can be traced to poor lighting conditions in the home.

CARD 5.

Housewives do not complain of the cost of the current consumed by appliances because they have been shown the value of doing things electrically.

CARD 6.

They believe lighting is expensive because they have not been sold on the value of having and using lots of it.

That is why today there are many appliances in homes that are only fifty per cent lighted. Surveys show this to be a fact. We do not wish to belittle the outstanding job done by the home service departments in building load through the education of consumers in the use of appliances, but we do say that home service should begin with lighting.

CARD 7.

Light is really inexpensive and it is necessary to emphasize this point constantly and vigorously. Domestic consumers must be reminded that the average living room can be lighted for several hours at the cost of a cake of soap or a few cigarettes, that the evening newspaper costs more than the light to read it by. They should be shown the relation of the bills for electricity with other bills. The average family spends more for ice cream, candy or tobacco than for light.

Today a relatively small percentage of the central stations have home lighting specialists developing domestic lighting business. In fact, this phase of their activity is comparable to the status of the central station commercial lighting departments six or eight years ago. We use the phrase "commercial lighting

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* Report of the home lighting committee, lighting bureau, Commercial Section. D'Arcy Van Alstyne, Edison Lamp Works of G.E. Company, chairman.
The Washington Water Power Company: Louie C. Aston, Ladner V. Ross, James E. Winton.

departments" to distinguish the present commercial and industrial lighting activity from home lighting activities. Six or eight years ago there were hardly a dozen definitely established commercial lighting departments in central station organizations. Now there is hardly a town of 25,000 population that does not have an illuminating engineer connected with the central station or a representative capable of giving advice on commercial lighting subjects.

In other words, home lighting has not received the attention it should command from central stations.

CARD 8.

I think you will agree that these facts must be admitted. First, that there are relatively few communities that are not now served by central stations. In this connection, the American Home Economics Association points out that every city in the United States of 5,000 population or above now has electric service as do:

97 per cent of all communities between 1,000 and 5,000,
50 per cent of all communities between 250 and 1,000,
And more than 25 per cent of all villages of less than 250 population.

CARD 9.

Second, that the domestic lighting field has the greatest potential possibilities of all lighting fields. This is indicated by the N.E.L.A. statistical bulletin No. 6, which shows the following figures for the year 1929:

CARD 10

| | |
|---|---|
| Domestic customers | 19,528,500 |
| Small light and power | 3,565,300 |
| Large light and power | 519,300 |
| Railways | 835 |
| Municipal, street lighting and misc. | 36,000 |
| Total | 23,650,900 |

A total of 19,528,500 or 82 per cent of the 23,650,900 central station customers are prospects for improved lighting.

The growth in the use of electricity in the home has continued to show a remarkable increase, outstripping the rate of growth of any other class of service.

There is a nice compliment for the home service departments in the promotion of the use of appliances, in the comparison of the results of surveys made some years ago and the recent J. Walter Thompson survey. The earlier surveys for a group of typical homes, showed that 83 per cent of the total domestic revenue was for lighting and 17 per cent for appliances. The J. Walter Thompson survey indicated 67 per cent for lighting and 33 per cent for appliances. The leading lighting authorities, however, believe that a 75:25 ratio is more nearly correct. But, regardless of what figures are chosen, the fact still remains, *lighting represents the largest portion of the total domestic revenue.*

As we are all familiar with the curves showing the downward trend in the number of newly wired old homes added each year to the central station lines, they will not be presented as part of this report. But we do wish to emphasize the trend toward apartment house dwellings and the fact that each year fewer one-family houses are being built. The average apartment has fewer rooms than the one family house and will therefore have a definite effect on the number of lamps burned and the amount of current consumed, unless the central station avails itself of every opportunity to influence the type of lighting installed. This influence can be exerted only through persistent contacts with architects, contractors and home owners.

CARD 11.

Important as this contact work may be, the revenue-producing possibilities of relighting homes now inadequately lighted cannot be overlooked. A nation-wide survey of several thousand representative homes in 1924 indicated the following:

| | Average Connected load Watts | Conservative Ideal Watts | Per cent Saturation |
|---|---|---|---|
| Living-room | 252.0 | 540 | 47 |
| Dining-room | 158.3 | 230 | 69 |
| Kitchen | 86.5 | 200 | 43 |
| Bedrooms | 98.0 | 190 | 52 |
| Bath | 70.9 | 100 | 71 |

As an example of the shoemaker's children going barefooted, we want to bring to your attention the results of surveys made in the homes of employees of two large central stations. The first survey included 698 homes and indicated an average connected lighting load of only 913 watts. The second survey included a similar number of homes with an average connected lighting load of 954 watts. This is only 45 per cent and 51 per cent respectively, of the conservative ideal figure of 1845 watts.

CARD 12.

There is still another condition which indicates the crying need for the development of the domestic lighting market. Beginning with 1926 and proceeding year by year, the average domestic rate has steadily decreased:

| Year | Average Rate | Difference |
|---|---|---|
| 1926 | $0.0699 | |
| 1927 | 0.0680 | $0.0019 |
| 1928 | 0.0655 | 0.0025 |
| 1929 | 0.0618 | 0.0037 |

It is interesting to note that the rate of decrease is accelerating each year. Assuming that the average per cent rate of decrease will be constant for the next five years, and this difference will equal $0.037 as in 1928 and 1929, an average domestic rate in 1935 may be $0.0436 per kw.-hr.

Based on the 1929 average domestic rate of $0.0618 per kw.-hr. for the life of the lamps, the revenue of a carton of 60-watt lamps in domestic service is $22.25. Five years from now the revenue value of this same carton of lamps will be only $15.69, or 70 per cent of the present day value.

The golden opportunity lies in the increasing of the present standard of lighting in the homes of these 19,528,500 domestic customers today.

CARD 13.

Let us consider, for a moment, the revenue-producing possibilities of one, or of all of the four following things in each of the 19,528,500 domestic customers' homes:

1. Filling an empty socket
2. Use of a higher wattage lamp
3. Creating a new socket
4. Longer burning hours

If we take each of these items and figure the revenue on the basis of the 1929 average domestic rate of $0.0618 for the normal life of the lamp, the figures are startling. They are more than startling when one realizes that they are entirely within the realm of possibility.

CARD 14.

Surveys indicate that 10 per cent of the lamp sockets in the average home are empty. Filling one empty socket in each of the 19,528,500 homes with a 40-watt lamp will account for $48,400,000 increased revenue.

CARD 15.

By inducing each of the 19,528,500 customers to replace one 40-watt lamp with a 60-watt, the total increased revenue will amount to $24,100,000.

CARD 16.

The addition of only one 60-watt lamp in each of these 19,528,500 homes will produce $72,700,000 increased revenue.

The sum of these three normal activities is the amazing figure of $145,200,000. But that is not all. There is a fourth activity—education.

CARD 17.

Through education, customers can be shown the value of using more light for longer periods of time. A 60-watt lamp burning one hour longer per day in each of the 19,528,500 homes will produce $44,000,000 revenue in one year, (CARD 18), or a grand total of $189,200,000.

CARD 19.

The starting point for capitalizing on these tremendous possibilities must be a sincere desire to do something concrete to promote home lighting.

CARD 20.

The second step consists of the adoption of a definite plan of operation and follow-up. We will not attempt to outline this plan further, as the plan is now being developed in detail by the national domestic lighting committee of the N.E.L.A. and will be presented to you by them at a later date.

The thing that we recommend is that you prepare yourselves to get your share of this tremendous increase in revenue.

CARD 21.

That the field is ready has been proved by the fact that 2,000 people read this lamp manufacturer's ad, the first of a series on home lighting, and were impressed enough with its message to fill in the coupon in the lower right hand corner of the ad, requesting a booklet entitled "How to Light Your Home."

CARD 22.

In conclusion, we wish to say that, with the present downward trend in rates, your net income will be lower within the next five years, unless you act now. That is why we say, "Now is the time to strike" and follow through by organizing a definite home lighting service.

TEXT OF CARDS

Following is the text of the cards indicated in the body of the report. These were hand lettered, standard size show cards, 22 x 28 in., mounted on a spotlighted easel and changed by the speaker at the proper time to emphasize the point desired.

*Card 1.*

MILLIONS OF DOLLARS SPENT FOR HOME ECONOMICS SERVICE

Teaching customers how to use electric ranges, refrigerators and appliances.

*Card 2.*

PENNIES SPENT FOR HOME LIGHTING SERVICE

Teaching people how to use the *one* thing that pays the largest part of the utilities' *total*—LIGHT.

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*Card 3.*

OUR RESPONSIBILITY

Eyestrain is the result of the improper use of the Utilities' principal commodity—LIGHTING.
(Photo of man reading)

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*Card 4.*

30 PER CENT HAVE DEFECTIVE VISION
(Photo of girl reading)

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*Card 5.*

HOUSEWIVES USE APPLIANCES FREELY
Because they have been shown the value of doing things electrically and therefore do not consider the current used by appliances expensive.

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*Card 6.*

NEED FOR EDUCATION

But housewives still believe LIGHT is expensive. They have not been sold on the value of having and using lots of it.

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*Card 7.*

COST OF LIGHTING THE AVERAGE LIVING ROOM FOR SEVERAL HOURS
—Equals—
A bar of soap
or
A few cigarettes
or
A newspaper

---

*Card 8.*

HOMES ELECTRIFIED
(Chart)

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*Card 9.*

EVERY HOME A PROSPECT
(Photo—Los Angeles at night)

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*Card 10.*

82 PER CENT OF YOUR CUSTOMERS ARE PROSPECTS FOR HOME LIGHTING

| | |
|---|---|
| Domestic customers | 19,528,500 |
| Small light and power customers | 3,565,300 |
| Large light and power customers | 519,300 |
| Railway customers | 835 |
| Municipal street lighting and misc. | 36,000 |
| TOTAL all customers | 23,650,900 |

19,528,500 or 82 per cent of the 23,656,900 central station customers are prospects for improved lighting.

*Card 11.*

THE REVENUE POSSIBILITIES THROUGH RELIGHTING OLD HOMES IS ATTRACTIVE

| | Average Connected Load Watts | Conservative Ideal Watts | Per-cent Saturation |
|---|---|---|---|
| Living-Room | 252.0 | 540 | 47 |
| Dining-Room | 158.3 | 230 | 69 |
| Kitchen | 86.5 | 200 | 43 |
| Bedroom | 98.0 | 190 | 52 |
| Bath | 70.9 | 100 | 71 |

*Card 12.*

STEADILY DECREASING DOMESTIC RATE

| Year | Average Rate | Difference |
|---|---|---|
| 1926 | $0.0699 | |
| 1927 | 0.0680 | $0.0019 |
| 1928 | 0.0655 | 0.0025 |
| 1929 | 0.0618 | 0.0037 |
| 1935 | 0.0436 | |

*Card 13.*

POSSIBILITIES FOR INCREASING REVENUE

1. Filling an empty socket
2. Use of a higher wattage lamp
3. Creating a new socket
4. Longer burning hours

19,528,500 domestic customers

*Card 14.*

FILLING ONE EMPTY SOCKET

In each of the 19,528,500 homes with one 40-watt lamp =

$48,400,000.00

*Card 15.*

USE OF A HIGHER WATTAGE LAMP

Replacing a 40-watt with a 60-watt lamp in each of the 19,528,500 homes =

$24,100,000.00

*Card 16.*

CREATING A NEW SOCKET

Add one 60-watt lamp in each of the 19,528,500 homes =

$72,700,000.00

*Card 17.*

LONGER BURNING HOURS

One hour a day longer burning of a single 60-watt lamp in each of these 19,528,500 homes =

$44,000,000.00

*Card 18.*

THE AMAZING TOTAL

| | |
|---|---|
| Empty socket filled | $48,400,000 |
| Use of a larger lamp | 24,100,000 |
| Creating a new socket | 72,700,000 |
| One hour longer burning | 44,000,000 |
| TOTAL | $189,200,000 |

*Card 19.*

THE STARTING POINT

A sincere desire to do something concrete to promote home lighting.

*Card 20.*

THE SECOND STEP

Consists of the adoption of a definite plan of operation and follow-up.

*Card 21.*

THE FIELD IS READY
(Edison Ad)

2,000 people read this ad and mailed the coupon asking for a book on home lighting.

*Card 22.*

NOW IS THE TIME

With the present downward trend in rates, your net revenue will be lower within the next few years.

That is the reason why we say NOW is the time to strike and follow through by organizing a definite

HOME LIGHTING SERVICE.

# *Outdoor Lighting**

AS a committee appointed to promote, review and suggest the possibilities of increased load and added revenue to be derived from the development of all types of outdoor lighting, it is our privilege to delve into heretofore untouched fields of central station endeavor and to discuss briefly the possibilities open to us in that particular field.

Even more than in the already developed channels of commercial lighting, covering industrial, home, commercial and advertising lighting, we find that the broad possibilities of outdoor lighting and the resultant load building through its various diversities present a most attractive field to the central station and one conducive to the best effort, the most careful study and increased activity of every central station.

### Street and Highway Lighting

Briefly, outdoor lighting is at present made up of several distinct divisions and quite naturally covers all forms of lighting lying outside the category of interior lighting. Street lighting, the oldest and best known, is a subject which is familiar to the oldest central station employee, it has its own history and its own political complexities, and its development has been gradual and in keeping with the progress of electrical development. The need for better street lighting in most localities is quite obvious to all of us and for its betterment it is essential that at all times we have before us as individuals and as lighting specialists a program that embodies a real selling plan, providing the latest developments and intensities in keeping with the communities, requirements and pocketbook.

* Report of the outdoor lighting committee, lighting bureau, Commercial Section. George E. Longmuir, Graybar Electric Company, chairman.
Allied Industries, Incorporated: E. A. Will.
General Electric Supply Corporation: J. H. Graff.

As an adjunct to street lighting, we now are face to face with the necessity of the adoption soon of its foster-sister, highway lighting. Since the advent of the automobile and its increasing traffic, the necessity for proper illumination of highways has and will become more increasingly apparent as public use for passenger and freight traffic grows and utilizes such highways more and more of the 24 hours of each day. Only as public funds become available may we expect development of this type of lighting, but, based on the highway construction costs per mile of paved roadway, the cost of illumination per mile would be comparatively small, and compensated for by increased traffic and usage. And yet the added kilowatt hours to the central station would no doubt approximate yearly a revenue of $500 per mile.

State governments, counties and even the federal government are spending millions of dollars developing our roads and highways and until such traffic thoroughfares are properly lighted, their use might be said to be limited in all safety under present conditions to twelve hours per day. Consequently, the relatively small investment and operating cost of proper lighting to provide 24 hours of continuous traffic provides an easy way to eliminate further capital costs and at the same time presents to the central station undreamed of load and revenue possibilities.

### Present Possibilities

So much for the future prospects. Let us now survey our present and fully realized possibilities, which take the form of floodlighting, utilitarian and decorative, recreational and sports lighting, seasonal and festival lighting and airway and airport lighting.

There is no service within the central station man's power to give or control that affords such general satisfaction to a customer or to the employee himself, as does a well executed lighting job. A well planned industrial lighting layout affording uniformly high intensities, a cleverly executed floodlighting job bringing out the architectural design of a building and a well thought out lighting scheme for a football or baseball field, all afford an actual eye picture of results, which, regardless of cost, is a source of real satisfaction to the customer, who measures his benefits, not only by what he sees, but by the effect produced upon his patrons.

### Floodlighting

Floodlighting for utility purposes covers only the actual lighting of large industrial areas, surrounding grounds of utility and service stations, yards and passage ways, and in the main its requirements are satisfied if reasonably priced and good quality apparatus is used, with low maintenance cost.

Floodlighting of buildings, whether for decorative or utility effect, must be exercised with due regard to the purposes to be accomplished. In this respect, the cheapest is not the best and rather than a poorly executed floodlighting job, it would better be none at all. Certain types of projectors are designed for specific beam effects and duties and due care must be exercised to select the proper equipment to meet the purpose.

Given proper leeway, the lighting man can make of your well planned edifice a thing of beauty by night, with its blending colors and stream line effects brought out by a well planned floodlighting job.

### Recreational Lighting

An opportune and timely subject right now is recreational lighting. This includes lighting for football practice, football fields and stadiums, baseball fields, tennis courts, swimming pools, golf courses and even race tracks. Each type of sport requires a different type and design of lighting, but in every case the industry, with the aid of the central station, has met the emergency and provided intensities suitable to the demands of the particular sporting activity. We have eliminated, with the better types of equipment, the obnoxious glare, and have provided the promoters of sports activities a real lifesaver in increased attendance and revenue.

Unfortunately, so far as the central station itself is concerned, the question of load factor, demand during peak load hours and revenue per kilowatt of demand has not as yet been fully ascertained and just how valuable such additional load may be remains for the future to tell.

### Airports and Airways

In the same category from a commercial standpoint, fall our airports and airways. The all-night lighting of airports and airways consists of beacons which must necessarily burn according to government regulations between the hours of sunset and sunrise. This also includes all airport boundary lights and any and all obstruction lights.

Field floodlights, however, which call for a high connected load are only burned while planes are landing or taking off, and as a consequence are low revenue producers in proportion to their demand requirements. Generally speaking, the spasmodic requirements of this type of lighting will gradually be more and more offset by the more general use of light and power in hangar and administration buildings at an airport, and the average demand and load to the central station will be more satisfactory, as the airplane industry and traffic expands and grows.

In closing, this committee cannot but feel that satisfactory progress has been made in the Pacific Northwest this past year. In every branch of outdoor lighting, notable installations in our territory have been installed and this year will add many more.

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## *Electrical Advertising**

IT is our fortune, good or otherwise, to be living in an age of publicity. Such slogans as, "Light Up for Better Living," "It's Toasted," "What Mother Really Wants," "Free-Wheeling," "Even Your Own Friends Won't Tell You," and many more, at the time of their utterance, definitely identify certain business institutions and the product or service they offer to the public. Advertising of every nature, in national publications, in local newspapers, on illuminated poster panels, by large electric signs, has so continuously placed the product and corresponding slogan of these various institutions before your eyes that these have become part of your vocabulary and as common as Model A Fords. Who then doubts this as an age of publicity?

The trend toward more elaborate and effective designing of advertising lighting is indeed interesting, especially when applied to theaters and amusement centers. Formerly a sign heralding the name of the theater was sufficient, with perhaps a running border of small multi-colored lamps and a small sign announc-

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* Report of the electrical advertising committee, lighting bureau, Commercial Section. H. C. McDaniel, Pacific Power & Light Company, chairman.
Edison Lamp Works: J. D. Wilkins.
Electrical Products Corporation: Bruce MacGregor.
Northwestern Electric Company: M. S. Glenn.
Portland General Electric Company: W. D. Williams.

ing the feature attraction. It is no mere coincidence that today the theaters are among the largest users of light for advertising and display purposes. The universal appeal to the mass, of brilliant light and flashing color, is known to those who direct such institutions and they are indeed taking advantage of this knowledge. The theater of today embraces all that is new and modern in electrical advertising. The ceiling of the marquee is jeweled with lamps, which at night flood the sidewalks with a pool of light. The feature attraction is usually heralded in brilliant colors on the face of the marquee. Sign design has assumed a trend to the vertical type, decidedly larger in size and architecturally co-ordinated, which makes for greater beauty and pictorial quality. Frequently the entire building facade is bathed in light, often in various colors, by a nearby battery of floodlight projectors.

Regardless of whether the theaters may or may not lead in this field of advertising, the fact remains that electrical advertising is good for any kind of business. Recall the patronage of your local theater or theaters as proof of this statement. With the theater attracting people of every age and the automobile providing a convenient means of transportation, more people are on the streets after dark today than ever before in history. Young people getting started in life are part of this crowd. They are in the market for household goods and scores of other necessities. The selling day is now four hours longer than it was a few years ago.

This almost necessitates some means of identification for after-dark hours, unless the store, office or bank are to sink into oblivion and become lifeless until the morrow, when they again become a living, pulsating factor in the business life of the community. Electrical advertising keeps alive the store, office or bank after dusk and makes it a living advertisement of the merchandise or service it sells.

The time is no more when you point with extreme pride to the bank or postoffice because they embody a particular style of architectural beauty and dignity, Modern business has discovered the advantage of erecting a dignified home, which architecturally is a credit and asset to the city, as well as to the business institution it houses. Because of this fact, banks and similar institutions, which in the past were known because of their particular type of architecture, have in recent years taken to electrical advertising.

Another factor entering into the value of advertising, electrical or otherwise, is location. Name the merchant who does not want to be on Main Street, where traffic is heaviest! In this location, hundreds of people pass his place of business daily, thereby placing a value on it during daylight hours that justifies the rent he pays for his location. When dusk falls, he turns to electrical advertising, which in turn makes his location profitable sixteen hours out of the day instead of twelve.

### Neon Signs

The Neon tube sign has met with considerable success in the Northwest, perhaps due to the fact that a live, energetic and well organized selling institution has been promoting its use for electrical advertising and also due to the fact that climatic conditions are favorable to the operation of this type of sign.

Gaseous tubes have certain advantages, such as vivid coloring, evenness of light throughout the letters, and economy in consumption of electrical energy. On the other hand, the maintenance cost of these signs is considerably higher than that of the incandescent lamp signs and the range of colors and possibilities of animated effects are limited. However, they add a touch of color to the high intensity white way street lighting that is employed, which is pleasing and attractive, adding a great deal to the view.

The tendency is toward the combination sign, employing Neon tubes and incandescent lamps. The animated effects are usually accomplished with the incandescent lamps. Some striking signs result from combining these two mediums of light energy. This combination is also helpful in correcting the poor power factor of the straight gaseous tube sign.

### Glass Letter Signs

The glass letter signs will always be popular, especially in the smaller communities. There is a dignity about these signs that is difficult to replace and they possess the quality of legibility for twenty-four hours of the day.

Utmost care must be exercised in the design of these signs, otherwise the letters tend to run together and the illumination of the letters becomes spotty. This type of sign is inexpensive to operate and maintain and it has an unusually low first cost.

### Exposed Lamp Signs

For color, animation, brilliance and real beauty, the exposed lamp sign has not as yet been excelled. The trend in moving effects in the larger signs seems to be to create flowing designs covering the entire area. The new small 10-watt, S-11 lamp, inside colored, is materially broadening the application of this type of sign, in that it permits construction of smaller signs that are objects of real beauty.

### Changeable Copy Signs

The demand for changeable copy signs is increasing. It is reasonable that it should. The advertiser naturally desires a change of message occasionally as evidenced by his newspaper advertisements and the displays in his windows and store interior. Such signs are now available and a great deal of development and progress can be expected in this field during the next few years.

### Floodlighting

There was a time when floodlighting was not even so much as considered as a means of electrical advertising. Today there is scarcely a large building erected that does not have incorporated in its design a complete floodlighting installation. Architects have come to realize what light at night can do in setting off the structure they designed, and as a result are quite receptive to the idea.

Nor do architects alone appreciate the value of floodlighting. One has simply to turn to service stations, golf driving courses, pee wee golf courses, store and building facades, to realize that a few business institutions have accepted this as a profitable medium of advertising after dusk.

### Market

Regardless of the foregoing discussion of electrical advertising, signs and floodlighting, the fact remains that but 25 to 30 per cent of all business institutions in the United States have electrical advertising at all and that most of this is poorly done and obsolete and should be replaced. The market is there. It is our job to develop ways and means of getting to the market.

This is indeed a problem, the solution of which would net someone his own stipulated figure.

### Methods

Some utilities employ their own sign salesmen, designers and manufacturers. Others employ salesmen and designers and have the signs made up by a sign manufacturer. Still others have an agreement with a sign manufacturer whereby they turn over all prospects to this manufacturer, who in turn does the actual selling of the sign. With such an arrangement, a concentrated effort is made to dig up prospects. The balance, it is regrettable to say, have no set plan of operation at all. They merely trust Dame Fortune for this business.

Undoubtedly there is no panacea. Each geographical section presents a different problem that must be analyzed by those familiar with conditions peculiar to that territory and handled in the manner most suitable.

The committee hopes that this report will act as a stimulant to the recognition of the value of electrical advertising. If this results, it will indeed be a big step forward, as it will mean that more people are telling the story of electrical advertising. The oftener the story is told, the sooner the customers we serve are going to put life into their stores when dusk overtakes us.

# MERCHANDISING BUREAU[1]

## *Water Heating**

MR. POST, in his opening address at the Commercial Section meeting, quoted Benjamin Franklin's reference to the fact that "ignorance begets prejudice."

Probably no phase of our business is more surrounded by prejudice than is electric water heating, due to ignorance of the subject, occasioned primarily by the newness of the art and by the fact that so little thought has been given to the subject.

The apparently low kw.-hr. rates necessary for securing this load have made most companies very backward about engaging in this business, overlooking almost entirely the high load factors possible. Even in the Northwest section, which has been so progressive in the introduction of electricity into the home, few of us realize that water heating revenue can be secured with a load on the system of only 0.7 kw. average per home which, when added where ranges are being used or are being installed, incurs practically no additional investment in the distribution system where the low wattage principle is employed.

Probably never before were power companies more in need of additional revenue without additional investment. Hence, the water heating load should be very appealing, coming as it does with very little increase in operating expense.

We have been prone to look upon water heating as something to be had as a bonus, if the customer agrees to use other service. Before water heating can come into its own, this view must change, as no other domestic item produces as much annual revenue in dollars and has such a high load factor.

Your committee has felt that little can be accomplished by presenting additional statistics, as practically all the Northwest member companies have had rich experience in this field and have access to the operating records of other companies.

### Simplification Is Desirable

We as a committee are very sympathetic with the opinion expressed by Mr. Post, that much can be done by way of simplification, both in rates and procedure, to the end that customers may be saved unnecessary "irritation." The residence problem can be made simple and has been made so by enough companies to prove the feasibility of simple rate structures, simple installations, and simple selling appeal, stripped of complications and mystery.

Arthur Brisbane once remarked in answer to the question as to what makes for commercial success, that the whole process is very simple—"Have what the people want and let them know you have it." Our electrical offerings have not always measured up to that specification. Wrapped up in our own studies we often unconsciously try to control the customer's behavior according to which procedure best suits the wishes of the power company, with utter disregard of the customer's wishes in the matter, and as a result we meet with only partial success in our undertakings. Your committee, while having no fault to find with any specific policies now existing or proposed, feels that a note of warning is not out of order at this time in connection with service limitations that, even in the slightest degree, annoy the customer in his attempt to make liberal use of electricity for all household needs.

### Danger of Off-Peak Preferential Rate

Your committee can conceive conditions under which "off peak" service or load limitations might be in order, but our discussions in committee meetings have developed the feeling that there is grave danger of future complications if, for instance, interconnection is ignored in making commercial plans. Many records are available and known to most of us of "off peak" on a single system becoming "on peak" on an interconnected system, with resulting customer difficulties upon necessary change of rates.

We feel that, wherever possible, water heating and, in fact, any other new load should be so introduced that the load curve will conform as attractively as possible to the expected ultimate characteristics of the system. "Off peak" schemes we think should take due account of the large number of residential customers and the great demand resulting if water heating becomes generally accepted. Without foresight, this large potential load might easily convert an "off peak" period into an embarrassing peak, with preferential rates which would have to be wiped out.

The water heating trend nationally seems to be toward low wattage, high load factor operation, with or without limitations, and our Northwest section is almost unanimous in this decision.

### Sell Complete Service

Your committee is of the opinion that we have much to learn along the lines of presenting our product, having in mind the complete residential problem. While we all look upon complete electrification as the desir-

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[1] L. W. Brainard, Idaho Power Company, chairman. R. B. McElroy, The Washington Water Power Company, vice-chairman.

* Report of the water heating committee, merchandising bureau, Commercial Section. H. M. Ferguson, Utah Power & Light Company, chairman.
Idaho Power Company: J. B. McLain.
Northwestern Electric Company: P. V. Perrin.
Pacific Power & Light Company: B. A. Hall.
Puget Sound Power & Light Company: M. T. Crawford.

able thing to accomplish, there are certain sales methods which the committee thinks might profitably be discussed at this time. For instance, range campaigns are very common with all of us, also refrigerator campaigns, and where campaigns covering single articles are carried on in sections having sliding scale meter rates of the combination type, through one meter, very often the addition of the range, coupled with the change to the new rate, results in little or no increase in revenue, and salesmen interested primarily in the commission to be earned in the selling of a range are using this fact to aid their sales work. If later, attempt is made to sell the water heater, the entire increment cost of operation is assessed against water heating, and, as a result, the general impression goes out that while electrical appliances generally are economical to use, water heating is very expensive. If, in contrast with the above sales policy, every proper pressure is applied to sell the water heater with the range, the resulting increase in bill seems reasonable for the two services, and the same high cost reaction is not present with the addition of the water heating load.

The same may be said of refrigeration when sold alone, or combined with water heating. With the combination sale, the increased electrical bill has generally a rather large off-set in the disappearance of the ice bill and the net increase in the customer's bill seems extremely reasonable for the two services. Of course, where possible, all three devices should be sold at one time, in which case the total bill seems entirely in line with the large amount of electric service enjoyed.

Growing out of this general thought, the committee feels that discussion of water heating cost alone on meter rates should be discouraged as much as possible, as the customer is interested more in the total cost of domestic service and the total service secured.

### Necessary to Make a Start

In closing our report, we should like to call attention to the continuing work of the committees, power companies, and manufacturers, in trying to work out all the details of this water heating problem. While this work should be commenced in so far as it can be made useful in promoting the sale of kilowatt-hours, we think there is danger of continuing it in the hope of solving all the difficulties before a general program of water heating is attempted. There are so many local conditions, both as to power system load curves, quality of water, etc., that it is obviously impossible to settle on a national water heating policy in advance of the start made by the individual companies. These companies will still have to develop many details in the local fields from initial experience. We quote from an eminent psychologist on this general subject, which extract we respectfully submit for your serious thought:

> Sometimes the difficulty of beginning work is due to the fact that we don't know precisely how to begin. Especially if the task is a novel one, the uncertainty results in procrastination. Some persons fortunately have a ready initiative; they seem to know by a kind of intuition how to plunge into any job, however unaccustomed. But most of us take hold of new work uncertainly, feeling and fumbling our way along. Here a plan is desirable, even though it covers only a few steps, and those experimentally. Thinking about the matter, baffling though it is, brings ideas of how to start, and thereby a path is made. One need not foresee the whole project in detail. It is enough to determine its initial steps and broad outlines. Generally speaking, all human affairs of importance have to be executed with a considerable measure of planning as the work proceeds. To wait for an inspired view of the whole before beginning is a common way of getting nothing done. Better far to do something, even if we cannot see a great way ahead, letting the further details develop as we go along. Ideas come more readily under the conditions of actual progress. Mistakes can be rectified.

## *Methods of Overcoming Sales Resistance to Range Wiring**

IN considering ways in which the electric range could be promoted in this territory, the electric range committee came to one general conclusion: namely, that the cost of electric range wiring to the customer is the outstanding resistance to the sale and installation of this device. The committee was fully agreed that if ways could be found to reduce or remove entirely this cost to the customer, a broader field would be open to the promotion and sale of electric ranges. Inasmuch as former reports of the committee have covered many other phases of range selling and range promotion, this year the committee decided to confine its report to a study of how this problem of overcoming the sales resistance to range wiring was being attacked by the individual companies. Several experiments, taking different forms, have been made in the territory, and the committee felt that an outline of these experiments would be valuable to all. The essential features of the various plans tried out or projected are, therefore, presented as follows:

### Portable Wiring Unit

One company has for some time been experimenting with a portable wiring unit easily installed and removed primarily to take care of rented houses. Practice has been to sell this wiring unit to renters at a flat price of $35, with the understanding that it would be moved from place to place at a cost of not more than $5 for each move, and with the further understanding that the customer could revert this equipment any time within two years for a credit of $30. The specifications for two such wiring units are shown in Fig. 1.

### Capitalizing Cost of Wiring

This plan was in effect during the year 1930 and proved to be of material assistance in the sale of ranges, particularly to renters. It is felt, however, that the resistance offered by the purchase price of this wiring unit is still a material factor in retarding electric range sales, and a way of getting around the necessity for charging the customer for the unit was

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* Report of the electric range committee. R. B. McElroy, The Washington Water Power Company, chairman.
The California Oregon Power Company: Glenn L. Jackson.
Idaho Power Company: F. M. Ingraham.
Pacific Power & Light Company: V. H. Moon.
Portland General Electric Company: Geo. Kumler.

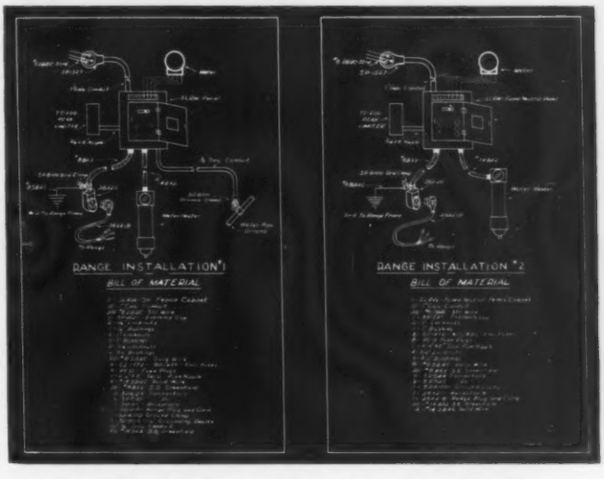


*Fig. 1. Portable wiring units used by one company.*

sought. After due consideration, the company decided to capitalize the labor and material going into the make-up and installation of this wiring unit, and, effective May 1, 1931, this policy went into effect.

The material for making up the unit is purchased by the company and issued out to the contractor-dealer who installs it on a contract basis at a figure representing a legitimate labor charge and a fair margin of profit. The company feels that this policy will make possible a much greater development of electric range business and will induce a greater effort on the part of other electrical appliance dealers to sell ranges, since all will be able to offer the range to prospects along with the portable wiring unit at the price of the range only.

Permanent range wiring, such as is usually installed, will not be capitalized. The customer purchases this wiring just as he purchases the balance of his wiring installation.

### Free Wiring as a Premium

Another company tried an experiment with free wiring in a range campaign in the summer of 1930. This was tried out primarily because it was felt that an unusual inducement would be necessary during the generally depressed business conditions prevailing at that time. The free wiring was offered in the nature of a premium and the cost of it was charged direct to merchandise sales as one of the costs of the campaign.

In spite of the unfavorable business condition, the number of sales during the campaign exceeded by 60 per cent the total number of sales made in similar campaigns in the past. The company attributes this success wholly to the free wiring offer. It is interesting to note that while the offer was expected to attract a great many rented homes, it was found that about 75 per cent of the sales were made to home-owners. Out of the 443 wiring jobs given free, 336 were to home-owners and 107 were to rented homes. There were 741 ranges sold during the campaign, 298 of which went into homes already wired, and to such purchasers the company gave a flat 10 per cent discount in lieu of the free wiring premium.

The average cost per wiring job for electric range and water heaters was $37.50. The company does not consider this cost exorbitant as an inducement for the installation of an electric range and water heater in view of the fact that in some previous campaigns it had offered a small price reduction plus premiums amounting to as much as $25 or $30 a range. It was apparent that the free wiring offer had a much greater customer appeal than any other special inducement ever offered.

Other dealers in electric ranges in the territory served by the company expressed concern that this free wiring offer would injure their business. When they were told that the offer was only temporary and was in the nature of an experiment, and when they were assured that if the offer were again to be made, the company would make it possible for all dealers to sell on the same basis, they withdrew their objections.

### Get the Landlord to Co-operate

Another company, recognizing the obstacle to sales of ranges to renters, represented by range wiring costs, has had some success in inducing the landlord to bear some of the expense of wiring his house for the tenant. In many instances, the renter is willing to pay a slightly higher monthly rent, if the landlord will wire the house for range use.

This company also sells range wiring on very low monthly payments, but it does not believe in furnishing free wiring, either charging the cost to merchandise sales or capitalizing it.

### Sell the Wiring With the Range

A fourth company recognizes the resistance represented by wiring costs, but believes this resistance can be overcome by proper selling. In other words, if the range is well sold the customer will be willing to pay for the wiring. This company maintains close relations with the contractor-dealers in the territory, who do the wiring, and carries the cost of this wiring for the customer along with the range contract with the payments distributed over the period allowed for payment for the range.

The company also assists the tenant in inducing the landlord to wire the house in which the tenant desires to use a range. It has been found, however, that many times when the landlord cannot be induced to pay for the wiring, the prospect has been so well sold that he pays for it himself.

For a time, a plan was tried permitting salesmen to quote wiring cost to prospects, based on a flat charge per foot of run. The unit cost was agreed to as satisfactory to the contractor-dealers for a type of wiring conforming to the code or ordinance prevailing in the territory. The intent was to simplify range selling by eliminating the necessity for the prospect to deal with a third party for this wiring with a period of uncertainty as to the ultimate cost of his proposed installation pending the receipt of one or more bids. This plan did not work out satisfactorily, however. The inexperience of the salesmen in the technicalities of wiring led to quotations of wiring costs based on a way of making the run to the range that later proved not to be feasible, thereby creating difficulties between all parties to the transaction. These difficulties appeared to outweigh the advantages and the plan was dropped.

### No Recommendation

The committee presents the foregoing as a summary of some of the plans and projects tried out or to be tried out by some of the companies. The members of the committee did not agree that any one of these plans is any better than another, but consider that the determination of what to do and how to do it is a matter for executive decision in each company.

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## *Refrigeration**

WITH refrigeration hardly out of its swaddling clothes, your committee had sufficient material with which to make a report comprising several volumes. The greatest good, however, from reports such as this one, comes from the active participation by the greatest number of commercially minded men in discussion of the several points presented. At best, only a brief analysis can be made of a few points, and it is the hope of your committee that these will only be the "bait" for deeper and more constructive thinking by our member executives, to the end that refrigeration shall become a profit-producing business for all who are

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* Report of the refrigeration committee, merchandising bureau, Commercial Section. H. W. Cooper, The Washington Water Power Company, chairman.
Idaho Power Company: S. J. Gray.
Northwestern Electric Company: J. C. Plankinton.
Pacific Power & Light Company: Guy E. Davis.
Utah Power & Light Company: J. F. McAllister.

engaged in its promotion, a good investment for the user and a satisfactory load builder for the utility.

### Organization of Committee Work

The importance of a close study of the subject of refrigeration is all the more pronounced, because of the three-year promotion program recently projected by the N.E.L.A. Upon announcement of the national program, your committee offered its services to the Northwest regional director, G. M. Gadsby. A meeting of all member sales and operating executives, and your committee, was called at Boise on Jan. 16. Every member of the committee attended and obtained full information of the national program. A separate meeting of your committee was held following the bureau meeting. By previous correspondence, subjects had been suggested by members of the committee, to be discussed at this meeting and to be included in the committee's report. Following the discussion, each member was given a subject to be prepared in such form that it might be included in the report. These sections of the report are as follows:

1. Dealer-Utility Co-operation in the Sale of Refrigeration ..... J. F. McAllister
2. The Sales Presentation ..... S. J. Gray
3. Price-Quality ..... J. C. Plankinton
4. Standardization of Models and Service ..... Guy E. Davis

### Subject Study

1. *Dealer-Utility Co-operation in the Sale of Refrigeration—*

In discussing the subject of dealer and utility co-operation, we shall try to analyze what has brought this idea forward as a serious problem for solving by the electric companies. We shall also attempt to give an outline for the solution.

Utilities of this country are now convinced that the domestic electric load is a very desirable one, especially in view of the experience just encountered, brought about by the business depression, which seems to be in evidence everywhere. This domestic load is just in the first stage of development and holds wonderful promise for future expansion.

Some utilities, who have been close enough to realize the value of domestic electric business, have been pioneering and promoting it by whatever means seemed to get the best and quickest results. It is well to remember at this point, that as long as most electric appliances were new, there was little to commend them to a merchant as a profit making possibility, until such time as public acceptance had been built up and a field created for their sale. Utilities, therefore, were forced to take the lead in popularizing electric appliances, and built up sales organizations, on whom the burden was placed for accomplishing a quick acceptance of these appliances by the domestic customer. How well these sales organizations have succeeded is evidenced by the fact that the independent merchants now recognize many domestic electric appliances as profit-producing possibilities.

To bring this condition about, the utilities adopted such means and methods as seemed best to obtain the desired result, having in mind that the more appliances in the home, the greater would be the use of kilowatt-hours. Some of the methods adopted by utilities were: Extensive advertising of specific items carried by them only, liberal terms for time purchases, bonuses to salesmen, special prices on the merchandise, premiums given away with other merchandise, wiring installed free or at a reduced figure, and various other things to break down the natural sales resistance to anything new. All of these methods are justifiable from the standpoint of the utility interested primarily in the development of the use of more kilowatt-hours. Profit from the sale of the merchandise could well be sacrificed as long as it assured a future use of electric current. The merchant, who has only the profit on the merchandise to rely on for his being in business, however, cannot afford to resort to the same means for getting his goods across the counter that the utility can, and, therefore, we are now faced with the complaint from the merchant that we are not carrying on our business in a legitimate manner, as it appears from his angle.

The manufacturer also enters the picture here, and because of the policy of the utility in looking only at the load-building possibility of the appliance and not the merchandising profit, the manufacturer may have a wrong impression of how his products can be placed in the hands of retail purchasers. The thought in mind is that in some cases the margin between a dealer's cost and selling price may not be sufficient to permit of aggressive sales effort and for that reason should be increased in order that the small dealer can maintain a sales force in the field and advertise his wares in a manner which will establish him in the highly competitive field existing generally today.

Some merchants take the attitude that by divine right they are entitled to the merchandise field and that the utility should be prohibited from entering it. This appears to be a somewhat selfish attitude. However, in promoting anything generally, the more people assisting, the greater will be the result. From this reasoning, anything which can be done to encourage the dealer in merchandising electric appliances should help the utility. A plan which takes into consideration both the dealer and the utility should be possible to produce, which would permit of the utility developing its domestic load at a rapid rate and still allow the merchant to participate in the merchandising of the appliances at a profit to himself.

It is entirely possible to co-operate and still compete and, therefore, the utility should stay in the merchandising business in order to further the development of the use of appliances and to insure the growth of the utility's business through their continued use. If the utility were to withdraw from the sale of domestic appliances, the move might be interpreted by the public as an admission that the appliances are not yet reliable. Also, without the utility's aggressive participation, the sale of appliances might be slowed up because of lack of competition.

The utility should advertise extensively, but should always include along with the specific, a generous amount of general advertising, which will benefit the independent merchant. Such terms as are advantageous to the utility to offer customers to create means for greater use of kilowatt-hours by using appliances, should also be made available to the dealer. This, perhaps, would mean handling the dealer's paper. This policy should be studied carefully so as to eliminate the danger of poor risks and the indorsement of substandard appliances. Also, the terms should not be radically different from the standard finance plans now available through large banking institutions, which otherwise would result in antagonizing this group. If it is desirable to offer special inducements to encourage buying by offering premiums, special prices, or free wiring, it would seem that these things should be made available for the dealer to offer, without his having to sacrifice his merchandising margin. Some thought should be devoted to whether the dealer can carry on business successfully on the margin now offered by the manufacturer. because, whenever it is not possible to do so, the utility is blamed for the condition, as the

dealer is under the impression that the utility has had a hand in establishing the prices.

Closer contact between dealer and utility, at which time mutual understanding is built up, should be fostered and sympathetic understanding of the dealers' problems should help in solving the problem now confronting the utility.

2. *The Sales Presentation—*

With the increase in demand and sale of electric refrigerators, comes the call for better sales—a call for an educational sales policy and the reconstruction of our sales presentation, a policy of 100 per cent satisfied customers. This can only be obtained by a careful grading of salesmen according to their sales ability. Careful analysis of refrigeration sales often shows that the salesman will follow the line of least resistance—that of selling an electric refrigerator too small to meet the demand in the home where it is placed. Each refrigerator sold should be in keeping with the social requirements and size of the home and family. With honesty to and confidence in himself and his company, the salesman cannot overlook this.

We must not take the friendly feeling of the public toward electric refrigerators to mean that they realize the savings to be made by owning one. The low cost of operation and the value of proper refrigeration to their everyday menus, as well as the guarding of the health of their families, are features overlooked by the average person. After all, are we not selling economical, convenient, sanitary electric refrigeration and not an electric ice-machine? Contact with the average prospect shows that he has very little knowledge of the advantages gained by the use of the electric refrigerator.

The ideal condition towards which business should strive is to make every customer a friend. This is the foundation upon which all successful business is built.

3. *Price-Quality—*

Surveys in certain territories show that 60 per cent of central station residential customers have incomes of less than $2,000 per year. No doubt, among the 40 per cent remaining, are to be found the present owners of electric refrigerators. With the present low saturation of electric refrigerators, there still remains, in the group of consumers above $2,000 incomes, ample market for the sale of electric refrigerators as now priced. There is, however, a feeling among the members of this committee that the manufacturers should give serious consideration to the matter of producing a popular low priced model, keeping in mind the absolute necessity of maintaining high quality to insure a minimum of servicing trouble and maximum customer satisfaction.

The low priced model might be possible of production by leaving all non-essential features off both box and cooling equipment. Too often, price reduction of an article is attempted through cutting down on quality of material and workmanship, but this is not the thought of your committee.

Your committee further feels that the suggested lowering of price be done without lessening the margin of profit to the dealer. In fact, we strongly feel that the margin of profit to the dealer at present on electric refrigerators is too small to encourage his full and enthusiastic participation in their sale. We feel that, with a satisfactory margin, dealers will put more effort behind the sale of electric refrigerators and, further, that more dealers will carry this line of merchandise. As we all know, straight merchandisers are interested in the profit that they are able to make through the sale of any particular item. They are going to give that item which produces the best return in the way of profit the very best space on their floor and their very best sales effort. It is also felt that central station and dealer relationship would be improved if the dealer were able to make a profit through the sale of electrical devices.

4. *Standardization of Models and Service—*

Turnover and obsolescence have always been determining factors in the profitable management of business. Therefore, the least number of models of electric refrigerators consistent with the demand, as to size, should encourage the manufacturer to greater profits in mass production; would reduce inventories of the manufacturers, jobbers, and dealers; would simplify and, therefore, strengthen advertising programs; and would stimulate sales through the psychology developed when Mrs. Jones says to Mrs. Smith, "Why, you have a refrigerator just like Mrs. Brown's. I believe that's the one we will buy."

Most conventional types of electric refrigerators now manufactured are so complicated as to service adjustments that the small dealer or utility outlet in the smaller community does not have competent serviceman facilities to maintain good service. This is not only expensive, but also one of the most evident factors which retard sales. Several manufacturers have eliminated this service criticism by providing units which must be returned to the factory and are always replaced with emergency equipment. The net result is greater satisfaction to the customer, greater profit to the dealers and increased sales to the manufacturer.

## Conclusions

From the foregoing, it will be noted that some of the problems discussed are common to merchandising of other types of electrical appliances. Their application to the merchandising of electric refrigeration is made, however, with the understanding that these factors are those which, at the present stage of development of the art, present the greatest problems and, therefore, require the most analysis.

*Dealer-Utility Co-operation—*

Much has been said about getting dealer co-operation. Some definite strides have been made with good results; many small factors still remain which discourage the small dealer from actively entering the refrigerator merchandising field. The dealer still believes that the utility has an advantage in the collection of installments because they are collected with monthly service bills. Inasmuch as utilities have profitably financed range sales for dealers, it is quite possible for the utility to make collection of refrigerator installments, where a reputable dealer will satisfactorily guarantee the contract.

It is now common practice for the utility to maintain the exclusive sale of leading makes of electric ranges. In the early stages of range promotion, this might have been justified when price reduction seemed necessary to obtain profitable saturation. Now, when ranges are selling at list, we find ourselves still without dealer outlets of any significance. From this experience, let us encourage dealer outlets for refrigerator sales during the pioneering stages and assure them that when they have developed something of a reputation along this line, the agency will not be taken from them and assigned to the utility.

*Sales Promotion—*

In the early sales of most appliances, "mechanics" held the most important place in the salesman's vocabulary. This same fault has been found in the sale of

refrigerators. National advertising has been built around "mechanics," with little effort made towards selling the service. Salesmen have followed, taking the line of least resistance. The projected campaign by the N.E.L.A. should do much to obviate this difficulty and prove the fallacy of the old method. Of all outlets, the utility should profit most by this procedure and should, therefore, point its advertising and sales effort to this end.

*Price-Quality—*

The manufacture of electric refrigerators is, for the most part, in the hands of large, well-managed, and well-financed organizations. Dealers may rest assured that design and efficiency improvements will be made just as fast as research divisions approve them. As costs of production decrease and sales increase, these should be reflected in a wider margin of profit, which should still further stimulate sales.

*Standardization of Models and Service—*

To be successfully sold in surburban areas, where highly specialized service men are not available, further simplification in design of electric refrigerators must be made. Any price a customer pays for poor service, however small, is too much, and represents a serious complaint, while most customers are willing to pay any reasonable price for good service.

### Summary

Your committee, therefore, recommends that:

1. Refrigeration is a profitable load.
2. Close attention be given to addition of sales outlets.
3. Improvements be made in the sales presentation.
4. The profit margin should be widened without too great a sacrifice in quality.
5. Careful attention be given to customer service after the sale.

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# *Report on Merchandising Activities of Electric Utility Companies in Oregon*[1]

THIS report will consider three questions: (1) What reasons have the electric utility companies in the state of Oregon for engaging in selling electric appliances? (2) Have these merchandising activities in recent years been of benefit to the users of central station electric service in the state? (3) Have these activities been of benefit to the other dealers in electrical appliances?

The report is prepared from data submitted by:

Portland General Electric Company
Northwestern Electric Company
Pacific Power & Light Company
Mountain States Power Company
The California Oregon Power Company.

These companies supply approximately 92 per cent (Note 1)* of the users of central station electric service in the state of Oregon.

[1] Report of the general merchandising committee, merchandising bureau, Commercial Section. Glenn L. Jackson, The California Oregon Power Company, chairman.
Pacific Power & Light Company: V. H. Moon.
Portland General Electric Company: A. C. McMicken.
Utah Power & Light Company: R. M. Bleak.
The Washington Water Power Company: R. B. McElroy.

* This note and subsequent note references throughout this report refer to supporting data, or actual documents not published herewith but retained on file in the office of the secretary for the information of interested persons.

### Introductory

As a starting point, it will be recognized that the electric utility companies of this state, in common with those of other states, have been important factors in promoting the use of domestic electrical appliances. The exact percentage of electrical appliance sales by electric utility companies to the total volume of such sales is not accurately known. A recent report (Note 2) on this subject by a competent authority estimates this percentage in the entire United States for 1930, at 30 per cent. This report goes on to state that in the larger cities the utility companies sell as little as 15 per cent of the total volume of sales, while in some of the smaller towns they sell as much as 40 per cent.

There are no figures available covering the state of Oregon, but it may be fairly assumed that the percentage of this business done by the companies reporting herein in the territories they serve is somewhat larger than the 30 per cent given as the national average.

## PART I

### Reasons for Utility Company Appliance Merchandising

There are valid reasons why the electric utility companies in this state have felt obliged to adopt a vigorous policy for the promotion of their domestic business through the sale of electrical appliances to customers. Some of these reasons are general in character and apply to the utility industry as a whole. Others bear more specifically on the particular conditions influencing the conduct of the utility business in Oregon. Some of these reasons are as follows:

### In General

*The Electric Utility, a Service Company*—An electric utility is primarily a service company. The public has delegated to the electric utility company the responsibility for supplying electric service, this function being one which the consumer cannot well perform for himself and one that the electric utility company is organized and equipped to perform effectively.

*Obligation to the Customer*—Involved in that responsibility is, first, the duty to furnish to the consumer an adequate supply of electrical energy. But when this is done the obligation of the utility company is not completely discharged. There is implied at least the duty on the part of the company, with its more informed understanding of the application of electricity to the customer's needs, to bring to the customer's attention the uses he may make of electric service in his own interest.

This duty, which has been fully recognized by the utility indusrty, has been given official recognition by the Supreme Court of Pennsylvania in the action brought against the Philadelphia Electric Company by Merchant & Evans. (Note 3.) In this case the court said, "Far from preventing the company from dealing in the converting devices needed, it would be our inclination to insist that it is part of its duty to furnish them to its customers."

This duty toward the customer, which as shown above is actual as well as implied, has been one of the reasons behind the aggressive development programs, involving appliance merchandising, of the utility companies.

There is another element of the utility company's obligations to its customers, namely the relation between the utilization of electric service and the price at which this service can be sold to the customer. As utilization is increased, the unit price of service can be, and is, reduced.

The utility company must build its physical plant to

meet a maximum demand utilized at the outset but a few hours a day for a few days of the year. The rest of the time a certain percentage of this physical equipment is working at only part capacity, and the company is receiving a lesser earning than the plant could produce if it could be kept operating somewhere near its full capabilities. Any utilization of service facilities that can be developed at hours other than the hours of the peak, can be supplied with comparatively little increase in the expense of rendering such service. Therefore this kind of utilization increases the net earnings of the company and becomes a major factor in the company's ability to reduce rates.

The obligation to serve the customer at the lowest possible rates consistent with sound operating of the business has long been a controlling precept in the utility industry. The fact that domestic rates have undergone continuous revision downward since the beginning of the business proves that this precept is being consistently practiced. An elaboration of this phase of the matter, as it has affected electric consumers in Oregon, will be found at another place in this report; but we desire to emphasize here that the increased utilization of service, as brought about in large part by utility company promotional activities and merchandising, has a direct bearing upon reduced costs of electricity to the consumer; also that the recognition by the utilities of their obligation to their customers in respect of these factors of cost and rates has been an actuating motive in utility company merchandising.

*Obligation to the Owners*—The foregoing discussion leads logically to another obligation of the utility company that has supplied one of the reasons for merchandising. Owners of their own businesses and managers of all corporate enterprises will recognize at once the obligation of management to its owners—the investors who have risked their money in the hope of securing a return.

Nor is consideration of the customer's interest in lower costs the sole stimulus toward reducing rates. You have already discerned, perhaps, that as increased utilization makes a lower rate possible, the lower rate in turn induces still greater utilization. It is a sort of endless cycle in the operation of which the company benefits along with the customer. Those in the utility business know, just as well as other business men know, that the way to make a business prosper is to make its product (in this case electric service) commend itself in price, quality and usefulness to the customer. This cannot be done by a policy of curtailment; it can be done only by a policy of extension and expansion, which works on the principle that as more service is utilized, the price of this service can be brought down so that still more utilization can be stimulated.

The company would be derelict indeed in its duty to its owners and, since the customer benefits too, to its customers, if it failed to take advantage of every opportunity to develop its business in every legitimate way. It would be particularly culpable if it overlooked the possibilities presented by the domestic field for such development.

Let us see what the possibilities are in this domestic field. The national viewpoint on this, as outlined in the report referred to above (Note 2), points out that there are 20,000,000 domestic customers now being served by the electric utilities in the United States. The average annual use of electricity made by these customers is 550 kw.-hr. The completely electrified home, however, will use about 8,000 kw.-hr. annually, and consequently the homes of the United States are only 7 per cent electrified. This analysis takes into consideration only those appliances for utilization now

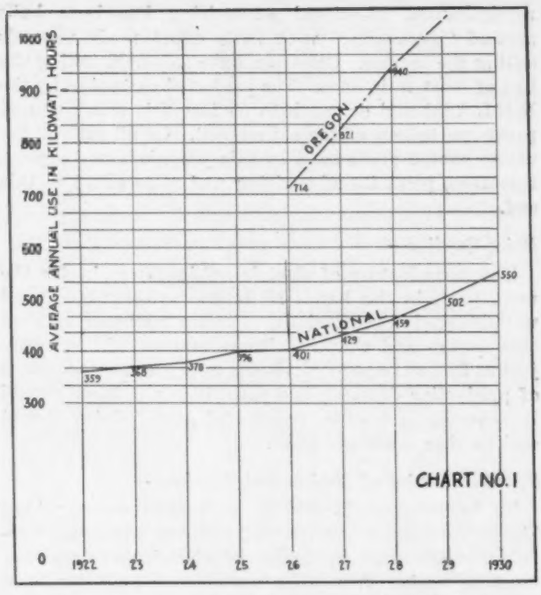


*Fig. 1. Average use of electricity per domestic customer. National yearly— 1922-1930. Oregon yearly—1926-1930.*

considered economical and practical, and omits consideration of future uses of appliances already in the laboratory stage of development which give assurance of still greater utilization. When it is remembered that manufacturing and general industry in this country is about 90 per cent electrified (Note 4), it is easy to visualize the importance of the domestic market to the utility companies and their customers, keeping in mind the obligations confronting the utility industry as outlined above.

### The Situation in Oregon

In Chart 1 is shown the average annual use of electricity per domestic consumer in the entire United States from 1922 to 1930. On it is plotted the average annual use in Oregon, from data submitted by contributors to this report, beginning with 1926. This chart shows that in 1926 when the national average was 404 kw.-hr. the Oregon average was 714 kw.-hr. In 1927, while the national average was moving up to 429, the average in Oregon jumped to 821. In 1928, the figures are respectively 459 national and 940 for Oregon. Beyond this point the Oregon curve moves off the chart, but since a chart for Oregon alone is presented later in this report you will have an opportunity to see how the average consumption in this state rose to 1,032 in 1929 and to 1,130 in 1930, compared with the national average for those years of 502 and 550, respectively.

A comparison between the national average and the Oregon average in cost per kw.-hr. to the domestic customer is also of special interest. These average costs for the past five years are shown on Fig. 2, the national average being shown by solid line and the average for the five Oregon companies reporting being shown by broken line. These two curves, indicating a decrease in the national average from slightly over 7 cents to about 6 cents or 14.9 per cent, and a decrease in Oregon from 4 cents to 3.04 cents, or 24 per cent, disclose two facts of prime significance. First, they show, when viewed in relation to the curves in Fig. 1 and to each other, the inevitable relationship between utilization and cost to the consumer, and how, as consumption rises, unit cost decreases; and second, they indicate, just as do the curves in Fig. 1, the wide difference between national conditions and conditions in

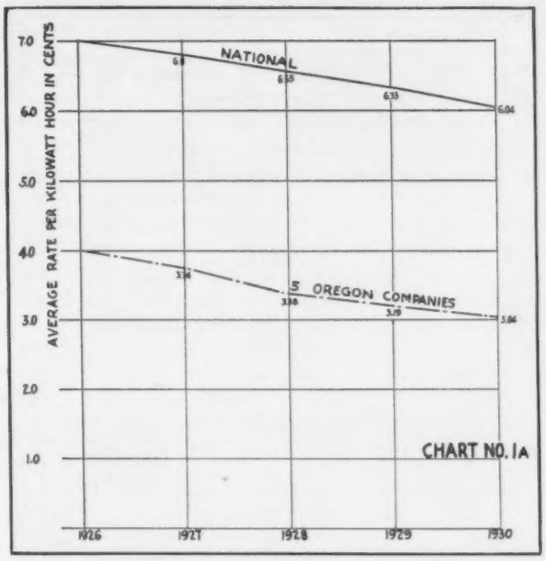


*Fig. 2. Average rate per kilowatt-hour domestic service—national and for five large companies of Oregon.*

Oregon. We will have more to say later in this report about the continually lowering cost to the consumer; here we desire to discuss the conditions in Oregon.

There is an explanation for this variation between the national figures and those of our own state, by which the domestic consumers of our state make double the use of electricity that is made nationally, and pay half as much per unit for it, and in this explanation is found one of the potent reasons why the Oregon utilities have engaged in merchandising domestic appliances. The explanation of why Oregon is so far ahead of the country at large in this respect is that the utility companies here, in common with other companies operating in the Northwest, started to develop the domestic field intensively before the companies operating in many other parts of the country. The reason they started earlier in this state was because they recognized earlier that in the domestic field lay their principal, if not their only outstanding opportunity for real growth.

Oregon is predominantly an agricultural state. It is not an industrial state, in the sense that New York, Pennsylvania and Illinois are industrial states, and its growth has not been along industrial lines. Thus when the utility companies serving the state had quite completely electrified industry in their territories and realized that further growth in the industrial and commercial fields would be relatively slow, they turned their attention, quite naturally and quite commendably, to developing greater use among existing domestic customers and to extending lines to new customers. We say commendably because of the benefits that have accrued to the people of the state from this policy—benefits more fully discussed later in this report.

Another fact bears on this same point and represents an important contributing cause for utility merchandising in Oregon. Due to the relative sparseness of the population in this state, the utility companies have been forced to build many more miles of line to serve the same number of customers as compared with many other companies serving more densely populated territory. During the 1930 On-to-Oregon campaign the slogan was "8-20-22" meaning that there were 22 people per square mile in California, 20 per square mile in Washington, and only 8 per square mile in Oregon, and that Oregon should strive to bring her ratio up to equality with her sister states. Incidentally, the average population per square mile for the United States is 35.5. For the utility company serving this character of territory, this means that a much larger investment in distribution facilities per customer is required, and this condition has furnished added impetus to the companies in Oregon to make that added investment produce a commensurate return by stimulating as much as possible the business obtainable from the relatively fewer customers available per unit of distribution investment. (Note 5.)

To sum up Part I of this report, the utility companies have entered the merchandising business in order to bring to their customers' attention the value and usefulness of various utilization devices; to continue to force down costs of service; and to stabilize earnings so that the industry would continue to attract the capital needed for its ever increasing expansion. At the same time added pressure has been existent in Oregon, due to a relative lack of major possibilities in the industrial field, and to the sparsely settled character of the territory and the resulting relatively abnormal investment in service facilities per customer. In short, the very life of the utility business, like the life of any other business, depends in large part on vigorously pushing the development of the business from within, and this vigor quite naturally and inevitably has led the utility companies into the business of promoting and selling electrical appliances.

## PART II

### Has Utility Company Merchandising Been of Benefit to the Public?

Having indicated the reasons why utility companies generally, and those in Oregon in particular, have felt it necessary to develop their business by engaging in the sale of domestic electrical appliances, let us further consider how and to what extent these merchandising activities have been in the public interest. Some of the benefits accruing to utility customers and to the general public have been mentioned in the foregoing; they will be more fully discussed, along with others that have not been referred to, in the following. These benefits, accruing to practically all domestic consumers of electric service in the state of Oregon, have been derived as follows:

1. Lowered average cost per kilowatt-hour to the customers, due to greater average consumption by means of electric appliances.
2. Lowered rates incidental to greater consumption and revenue.
3. New appliances introduced to the market through pioneering by power companies.
4. Labor saved in the home through bringing about a wider use of electricity.
5. Better electrical service through necessity on the part of power companies of furnishing continuous and adequate service to the appliances they have sold.
6. Electric service brought to many who would otherwise not have been reached.
7. Better quality of electrical merchandise in use.
8. Improvements in personal service to the customers resulting from additional contacts with them through merchandise sales.

1. *Lowered Cost Per Kw.-Hr.*—A continually decreasing cost per kilowatt-hour to the customer has accompanied a steady rise in the average consumption of the customer due to the aggressive load building activities of the companies reporting herein, through the sale of electrical appliances. This fact is born out by the figures submitted by the reporting companies in which each company has shown its increasing average

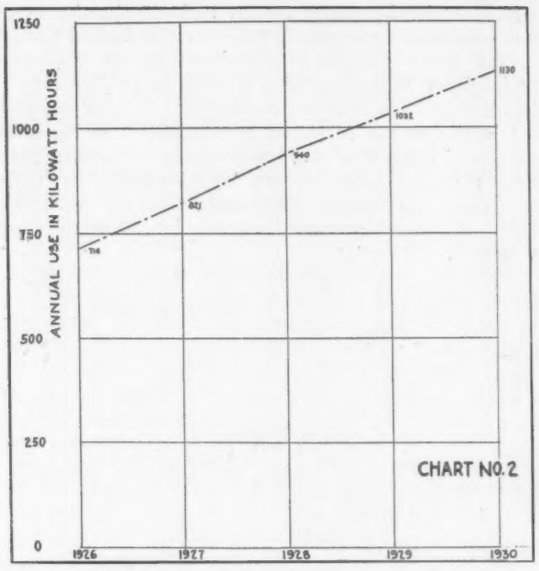


*Fig. 3. Average annual kilowatt-hour use per domestic customer, 1926 to 1930 inclusive—combined average for five large companies of Oregon.*

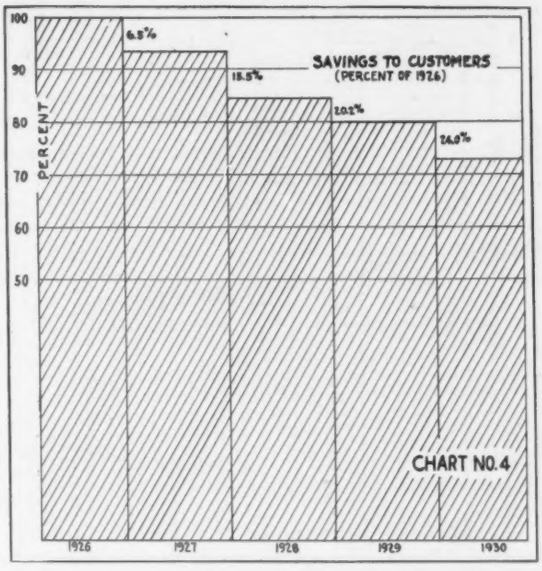


*Fig. 5. Decrease in average rate per kilowatt-hour, domestic service, 1926-1930 inclusive. Combined average of five large companies of Oregon. Taking the average rate for 1926 as 100 per cent, the average rates for the succeeding years are expressed in terms of per cent of 1926.*

consumption and its decreasing average cost per kw.-hr. for the past five years. The average for the state computed from these figues shows, Fig. 3, that there were 714 kw.-hr. consumed per domestic customer in 1926 and 1,130 in 1930. During the same period the average cost per kw.-hr. went down from 4 cents to 3.04 cents, Fig. 4, representing a decrease of 24 per cent, Fig. 5. (Note 6.)

The reason why decreasing cost so closely accompanies increasing consumption becomes apparent when you examine the rate structures of the companies reporting. Invariably these rates are what are termed "inducement rates," making low priced kilowatt-hours available to the customer who will build up his use of kilowatt-hours over the various hours of the day, for the greater part outside of the peak period. Under many of the rates in existence in Oregon individual customers approaching the maximum use of electricity in the present electrified home, of 8,000 to 9,000 kw.-hr. annually, get their service at an over-all cost of slightly over 1½ cents per kw.-hr. (Note 7.)

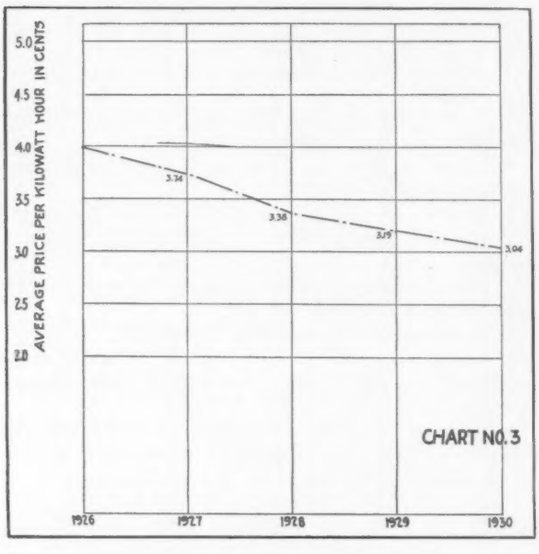


*Fig. 4. Average rate per kilowatt-hour, domestic use, 1926-1930 inclusive. Combined average for five large companies of Oregon.*

The establishment of rates that will produce this effect is a major aspect of the policy of the Oregon utility companies, namely, to expand the usefulness and economy of their service in the domestic field, in the belief that this usefulness and economy will be utilized by customers to the advantage of both the company and the customer. But the mere making of rates is not sufficient. It is necessary to bring the advantages of these rates to the attention of the customer by showing the customer what appliances he can use in his own interest, and the accomplishments thus far recorded in this direction could not have been possible without an aggressive promotional policy that has included merchandising of appliances.

2. *Lowered Rates*—The benefit that has come to the customer in lower average cost due to his increased consumption has contributed to a further benefit to him in rate reductions, made possible by the companies' increased revenue from the customer's increased consumption. This point has been discussed at length earlier in this report and need not be elaborated further here. That it is an actual and not a theoretical result is evidenced by the rate reductions made by the reporting companies in the last five years.

3. *New Appliances*—It is generally recognized that, if the utility companies had not in the past been aggressive in the pioneering of the sale of electrical appliances, the introduction of new uses of electricity in the home would have been greatly retarded. Each new appliance brought out by manufacturers for the market has required a large amount of promotional effort behind it, before sufficient public acceptance of the appliance was created to make the appliance practicable from a merchandising standpoint. This has been true from the early days of the development of appliances for home use, beginning with the flat iron and extending on through the most recent appliance, the sun lamp. Some appliances have required more promotional effort than others, notably the range, water heater, washing

machine and ironer; and this promotional effort has been supplied, at least in the pioneering stages, very largely by utility companies. Even the electric refrigerator did not achieve its present public popularity without considerable promotional effort on the part of the electric utilities over the entire United States.

The introduction of these new appliances has contributed to lower average costs and lower rates and the utility company's part in this pioneering and introduction of new appliances through merchandising to its customers has therefore been a benefit of paramount importance to the public.

4. *Labor Saved*—It is unnecessary to point out how the application of electricity to home tasks has lightened home labor and brightened living conditions. We shall pause here only long enough to point out that in so far as utility company merchandising has been responsible for hastening the condition of comfort and convenience found in the average Oregon home today, due to its intensive use of electricity, such merchandising by the companies has been a contributing factor to Oregon's progress and well-being.

5. *Better Service*—A continuous improvement in the service facilities of the utility companies has accompanied their promotional efforts directed toward inducing this intensive use of electricity in the home. It was recognized that if their customers were to secure the maximum benefit from the use of electrical appliances they had been urged to install, and if the companies were to realize the maximum results in the sale of kilowatt-hours used by those appliances, a continuous, steady and reliable service would have to be rendered.

Steps in the process of improving service facilities have been, historically speaking, first, the establishment of 24-hour service in those communities formerly receiving service only during the hours of darkness; second, the extension of lines into outlying communities; and third, the strengthening of all lines physically to withstand severe weather conditions to minimize outages, and electrically to deliver the proper voltage at all times to the point of use so that customers' appliances would operate in the way in which they were intended to operate. Such improvements, begun early in the history of electrical development in Oregon, deriving added impetus as time went on from the growing utilization of electricity fostered in part by the merchandising and load building activities of the utility companies, and continuing unabated today, have resulted in a class of service in this state unsurpassed anywhere in the United States.

6. *Extension of Service*—The intensive use of electric service found in Oregon brought about by the aggressive promotion and sale of merchandise by the utility companies has been a large contributing factor in the extension of service to farms and scattered rural communities. Without a relatively high average earning per customer in the cities, and without the knowledge of what service could be used satisfactorily in the home gained through pioneering this business in cities, the utility companies could never have undertaken the extensive development of rural territory that has brought central station service to more than 16,000 Oregon farms. Active utility company merchandising has therefore contributed largely toward benefiting the farmers of the state by making possible this extension of rural electric service.

Bearing on this point the Topeka, Kan., *Capital* in its issue of Feb. 1, 1931, editorializes as follows about pending legislation in the state of Kansas.

> There is a bill in the legislature prohibiting electric power companies from selling electrical appliances. Turning it around the other way, it is an attempt to set back the electrification of farms for a generation by dictating to farmers from whom they may buy appliances to make the farm home a better living place. The electric power industry is extending electrification and consequently it is particularly interested and takes pains and expense to get to the farmer to "sell" him electrical appliances for the home. The promoters of this legislation, whoever they are, want the state by law to forbid the farmer from buying from these concerns, the only interest in the country that can afford to and does go to the farmer and puts before him the advantages and opportunities to mitigate farm home drudgery by various devices of electrification. (Note 8.)

7. *Better Appliances*—It is a well known general fact that in communities where the utility company merchandises electrical appliances, the average quality of these appliances is higher than in communities where the power company does not merchandise. One reason for this is that the principal burden of appliance servicing, no matter who does the selling, falls on the power company repair service department. In order to keep the expense of such department at a minimum, the power company is necessarily interested in seeing that its customers use electrical merchandise of the highest possible quality requiring a minimum of repairing.

Another reason for the power company's interest in high quality appliances is that broken or worn out appliances are not used, and use means kilowatt-hours consumed. Further, well made appliances deliver the service for which they are intended when cheaper appliances fail, and thus quality appliances increase the popularity of electrical appliances generally. Last but by no means least, good appliances are safe, while cheap ones represent a fire and accident hazard that on occasions has implicated the utility company, whether unjustly or justly, in damage suits.

Some of the less responsible or less vitally interested dealers in electrical appliances have frequently been induced by appliance manufacturers to handle appliances of questionable grade or efficiency, to the ultimate disadvantage or loss of the consumer. This, of course, is not true of the better informed and more responsible dealers, but it is generally recognized that in communities where the utility company does not set the pace in electrical merchandising, the quality of the merchandise sold has not been as high as where utility company merchandising has been vigorously promoted. The public interest demands appliances of the highest quality from the standpoint both of safety and service to the user, and this standard has been fostered continually by the utility companies of Oregon in their merchandising activities.

8. *Improved Personal Service*—Incidentally there has been a genuine gain in the personal service rendered to customers by the utility companies, resulting from the contacts of the company sales representatives. Through these salesmen, and through the home service departments operated as adjuncts to the merchandise sales department, minor repairs to customers' appliances have been made with great convenience to the customer, and useful information on the proper manner of using appliances has been freely given, so that the general usefulness and economy of electric service has been enhanced.

To sum up this part of the report, it is apparent that utility company development activity has increased the use of electricity resulting in lower cost per unit and lower rates; it has introduced new appliances to the public; it has raised standards of living and minimized labor in the home; it has contributed to the improvement in the quality of the electric service rendered by utility companies; it has made possible the more rapid development of farm electrification; it has raised the quality of appliances used; and it has en-

hanced the usefulness and attractiveness of electric service. These direct public benefits affecting practically all the users of electricity for domestic purposes in the state, could not have been possible without an aggressive attitude toward the development of their business on the part of the utility companies, including in such development the sale of electrical merchandise.

## PART III

### Has Power Company Merchandising Been of Benefit to Other Dealers in Electrical Merchandise?

Some of the elements entering into a consideration of this question are intangible and require comment before proceeding to discuss the main features of the question.

#### Character of Electrical Merchandise

*Electrical Appliances Not Demand Merchandise*—Some of the off-hand discussion of utility company merchandising proceeds on the assumption that there is a fixed volume of demand business in any locality for electrical merchandise, and that all of this volume, if the companies were not in the appliance business, would be divided as an increase among the other dealers. Experience shows that this assumption is mistaken. Electrical appliances are not demand merchandise. They cannot be sold as groceries are sold. If they are to move in any considerable volume, a continuous promotion is necessary. This necessity for a continuous promotion of the whole line and for pioneering of newer and constantly improving products is, as has been shown, one of the important considerations causing the power companies to engage in the distribution of appliances.

Speaking generally, the non-utility company electrical dealers have never yet demonstrated a willingness to undertake this pioneering and promotion. Perhaps this is because under existing prices of electrical appliances, and under the prices that have obtained in recent years, there has not been a sufficient margin of profit in many items to make this required promotional effort economically possible to the general merchandiser or storekeeper from a merchandising standpoint. This is a matter over which the utilities, of course, have no control, but they have learned by experience that if they are to develop their business in the expectation of producing the results referred to in the earlier part of this report, they must themselves engage in the sale of the appliances and undertake the pioneering and promotion that goes with this activity.

*Trade Discrimination*—Many non-utility dealers sell electrical appliances only as an incident to their other business. This is true of department stores, hardware stores, drug stores and others selling electrical appliances who at the same time offer a variety of other commodities to the public. If utility companies were to go out of the merchandising business, it is probably true that at least some of the money now spent for electrical merchandise with the utilities, being a part of the community buying power, would be diverted to the stores of the other dealers. But this does not imply that the buying power so diverted would go in any major proportion into these other dealers' electrical merchandise. Much of the buying power so diverted would naturally go into other forms of merchandise on which the storekeeper will make more margin of profit and therefore be willing to put more selling effort behind. The effect of utility company retirement from the merchandising business would inevitably be the slackening up of electrical merchandising, at the expense of the electrical industry and its customers, to the doubtful advantage of those interested in promoting the sale of other goods.

#### Benefits to Dealers

Analysis of the activities of the utility companies in merchandising electrical appliances and their results will disclose three main classes of outstanding benefits to merchants and electrical dealers other than the utility companies:

1. *Wiring Business Created*—In the first place, the promotion of the use of electric ranges, water heaters, refrigerators, washing machines, ironing machines, vacuum cleaners, better lighting and all manner of other appliances, has created a tremendous amount of electric wiring to make utilization of these devices possible. The business of installing this wiring has fallen almost entirely into the laps of one class of electrical dealer, the so-called contractor-dealer. Much of this wiring business, particularly that for ranges and water heaters, would never have been created but for the promotional effort on these devices applied by utility company merchandising activities.

2. *Appliance Market Widened*—Secondly, the decreasing costs of electric service and the decreased rates referred to in the earlier portion of this report have meant increased opportunity for the consumer to utilize electrical equipment. This has inevitably opened up a wider market for the sale of electrical appliances—a market for all of the general store owners and others dealing in electric appliances, that would not have existed had utility companies adopted a less aggressive policy of business development.

3. *Dealers' Trade Volume Increased*—The utility company, in promoting the sale of any article of electric merchandise, aims to "sell" the idea of the convenience and benefit of that appliance to the public. Its primary object is to persuade the customer to use electricity for the purpose required by this appliance, and its advertising and publicity for this appliance stimulate prospective buyers' interest in all appliances for this purpose offered for sale by any of the dealers or storekeepers.

When the utility company pushes the sale of some make of electric refrigeration, it is actually persuading the public of the advantages of electric refrigeration generally. It is helping to sell not merely the particular machine it calls attention to, but all other standard appliances for the same purpose; and its campaigns probably do more to promote electric refrigerator sales by other dealers, whether in the same or some other machine, than any one of these dealers could normally accomplish by his own unaided efforts. The same is true of electric washing machines, electric irons, toasters, ranges and all other staple appliances. The utility promotion of this merchandise helps to create the market, which in large part is enjoyed with profit by all the dealers.

In addition to this semi-direct stimulation of dealer sales by the utility companies, the latter in Oregon and elsewhere have done a large amount of appliance advertising in direct partnership or joint undertakings with the other dealers. Much advertising is done, and doubtless more will appear in the future, as trade relations are better co-ordinated, whereby the appliance is featured as a desirable article for the user, with the names of not only the utility company but of other dealers in the appliance prominently featured in the display. This method of co-operation is susceptible of indefinite adaptation and growth, and the utilities' part in it to date has been a splendid example and demon-

stration of the utility company's fairness to the general dealer. It supplies a striking evidence of the desire of the utility company to help the dealers to develop their appliance business profitably, while the utility is working to perform its public duty of building up load for the benefit of its present and future consumers.

It is quite evident from the foregoing and from any candid appraisal of the past record, that the dealers' appliance market has been and is being largely created by the utility company's activities, and that the dealers collectively and individually, as well as the public generally, have benefited immensely from appliance merchandising and promotion by utility companies.

### Conclusion

*A Question of Methods and Practices Rather Than Principle*—In conclusion, it should be understood that the discussions which have waged around this question of utility merchandising, as between the utility companies on the one hand and the electrical dealers on the other, have had varying aspects in different parts of the country, from minor local squabbles to court cases and proposed state legislation. However, out of all this discussion have come a better understanding of previously misunderstood individual points of view, and a clearer conception of the real problem with all of its implications. There is a general feeling now on the part of all concerned that it is not so much a question of the right or propriety of utility companies engaging in electrical merchandising activities as it is a matter of adjusting specific difficulties which have here and there arisen in merchandising policies and practices.

*A Matter of Self Regulation*—This being the case, the problem is one for regulation by and between the parties immediately concerned. Such regulation has taken place elsewhere to mutual satisfaction, and it is only good common sense to apply that sort of remedy everywhere.

That the question is being treated in this light by the leaders in the utility industry and in the businesses represented by the other electrical dealers, is evidenced by the meeting (Note 9) held Feb. 9, 1931, in New York, at which the following were present: representing the utilities—Charles L. Edgar, president, Edison Electric Illuminating Company, Boston; John F. Gilchrist, vice president, Commonwealth Edison Company, Chicago; C. E. Groesbeck, president, Electric Bond & Share Company, New York; J. F. Owens, vice president and general manager, Oklahoma Gas and Electric Company, Oklahoma City; Marshall E. Sampsell, president, Central Illinois Public Service Company, Chicago; M. S. Sloan, president, The New York Edison Company, New York; W. R. Putnam, commercial department, Electric Bond & Share Company, New York; and representing the other dealers—D. F. Kelly, president, The Fair, Chicago; R. J. Atkinson, Ralph Avenue at Broadway, Brooklyn; Harry F. Cappel, Cappel Furniture Company, Dayton; A. Lincoln Filene, Wm. Filene's Sons Company, Boston; Lew Hahn, president, Hahn Department Stores, Inc., New York; Alfred B. Koch, president, LaSalle & Koch Company, Toledo; and Mr. Strauss, president, Macy & Company, New York.

This group formed from among its numbers a standing committee to be known as the electrical merchandising joint committee, consisting of six representatives of the utilities and six representatives of the other dealers, with Mr. Kelly as chairman. The joint committee agreed to undertake a factual study of the policies and practices now followed in the promotion and sale of household electrical appliances, to determine what practices cause misunderstanding and what practices have proven most sound and successful. From this study the committee expects to be able to suggest ways to bring about mutual understanding, and methods of stimulating household uses of electricity in a manner to promote the business interests of all. (Note 10.)

It would appear that, when men having the standing in their respective industries attained by the men listed above recognize the importance of the situation sufficiently to focus their collective attention on the problem, the interested parties everywhere may reasonably expect a satisfactory solution.

*The Real Job—Co-operation*—In the meantime, the utilities in Oregon have not overlooked the gravity of the situation, and various companies have taken steps to adjust their merchandising policies and methods with a view to removing the main causes of dealer complaint that have come to their attention. The companies fully recognize the value of having other responsible dealers aggressively selling electrical appliances. They know that every worthy appliance sold to go on their lines adds kilowatt-hours and revenue. They want the co-operation of the other dealers, and the dealers, as they understand the value of utility company promotional activity, want the co-operation afforded by this activity. It is, after all, a job for co-operation, particularly when the magnitude of the market is viewed in proper perspective and it is realized that the job is big enough to tax the energies and abilities of all concerned. In the working out of this co-operation lies the hope of the dealer and the utility company alike.

Whatever differences exist, we believe, will be composed by the parties to those differences. And we ask all concerned to recognize that the utility companies of Oregon have adopted an aggressive program of business development, which has included the merchandising of appliances, as a necessary part of their obligations to their customers and to their owners, and that this aggressive program has benefited all dealers in electrical merchandise, as well as the utility customers and the public generally.

# POWER BUREAU[1]

## *Electrification of Lumber Mills**

IT is the intention of this report to review the factors controlling the electrification of lumber mills, and to give particular attention to the problems involved in the more recent electrical applications, including the Scandinavian gang saw applications. Previous studies

[1] T. M. Gibbes, Puget Sound Power & Light Company, chairman. H. B. Batchellor, Puget Sound Power & Light Company, vice-chairman.

General Electric Company: Sam Mitchell.
Northwestern Electric Company: R. W. Faville.
Pacific Power & Light Company: B. P. Baily.
Portland General Electric Company: J. D. Scott.
Utah Power & Light Company: Glenn B. Walker.
The Washington Water Power Company: Arthur H. Wegner.
Westinghouse Electric & Manufacturing Company: E. T. Naden.

* Report of the power committee, power bureau, Commercial Section. H. S. Atwood, Puget Sound Power & Light Company, chairman.

of this subject have been largely directed to the details and engineering problems involved in the application of electric power to lumber mill machinery. It is intended here to review these applications as they are concerned with the economic and operating advantages derived from electrical power.

The electrical industry has a dual interest in the electrification of lumber mills. Equipment manufacturers are interested in this outlet for electrical machinery, while the light and power companies are interested in this market for central station energy. Although the installation of electric drive does not necessarily mean the use of central station power, these two branches of the electrical industry co-operate closely in this work. The greatest gain to the industry lies in the complete electrification of drive, together with utilitzation of central station power.

*Advantages of Electric Drive—*

The electrification of practically all of the recently built mills demonstrates the advantages of this drive. However, the use of central station power is dictated more closely by local conditions and by recent tenddencies in the lumber industry. The first electrification of lumber mills has been primarily due to advantages of electric distribution and application of power over steam distribution and application. There was very little consideration of the saving in fuel involved, as this fuel has been the waste sawdust of the mill, which heretofore has had no value.

The electrification of lumber mills has been justified by the reduction of labor costs and the reduction of machinery maintenance costs. The saving of labor costs through electric drive are manifold. Constant speed characteristics of electric motors maintain a more constant speed of production over steam power. This results in an increase in production with the same operating force. The development of special motor applications greatly simplifies the movement of lumber through the mill. Automatic push-button control reduces the working force necessary to control the power equipment and speeds the passage of lumber through the mill. The elimination of clumsy line shafting and belt transmission of power throughout the mill reduces the time of delays due to failure of equipment very materially, which is one of the most important advantages of individual electrical drive. The elimination of costly accidents due to exposed line shafting and belting has a major consideration in the electrical design.

Due to the limitation of mechanical transmission of steam power, the larger mills required the installation of at least two, and often more, complete power plants on their premises. Each of these plants required a complete set of boilers, engines, pumps and auxiliary equipment, together with a full operating force. The sawmill required one power plant, the planing mill another and any additional plant, or remote drive, required either another plant or an expensive shafting transmission of power.

Direct electrical drive not only eliminated the duplication of operating force required by these several plants, but effected a very considerable saving in the heavy maintenance costs of the plants, together with the steam engines, belt drives and line shafting equipment. Where central station power was not used, the investment in electric generating equipment, together with the cost of individual electric drives, frequently exceeded the cost of the additional boiler plant and steam engine equipment. However, the saving in maintenance and labor costs more than justified the additional investment.

*Use of Central Station Power—*

The economies of central station power, as against the use of an individual power plant, in the earlier stages of electrification was primarily a matter of balancing the investment maintenance and labor costs of a power plant against the cost of purchased power. Since fuel was considered a waste product of no value, this item was not a factor. There were other factors, such as the cost and availability of water, availability of surplus power at low rates, space provisions and the attitude of the management relative to the diversion of capital resources to power plant equipment. As a result of these conditions, many of the earlier electrical applications included the construction of individual power plants. A typical mill of this type is the Booth Kelly Lumber Company plant at Wendling, Ore. Installation and test data on this mill are appended to this report.

During the last few years a new set of conditions is becoming effective, tending to place central station power on a more favorable competitive basis. A summary of these tendencies is as follows:

1. Less waste fuel by greater utilization of logs for lumber.
2. Development of a market for sawdust and lumber waste—
   a. Hog fuel used for heating homes, commercial heating plants, and process steam production.
   b. Use of sawmill waste by pulp and paper mills.
   c. Other uses of waste products, such as building materials, sawdust, brick, etc.
3. Development of additional lumber manufacturing processes requiring more power than original plants provide.

Local conditions often become dominant factors in the selection of central station power for the electrification of older mills. Sawmill boiler plants are often entirely inadequate for supplying the additional load of the other sections of the mill. Addition of power application from the rest of the mill adds a greater burden to the saw mill plant. The older boiler and power equipment is subject to heavy maintenance costs and more frequent delays due to break down of equipment, repairs and inspections. Central station power has the advantage of permitting additional loads without further delay or investment in plant equipment. Under these conditions, mill operators are hesitating to place additional investment in power plant equipment that may later use fuel of value as a by-product. By purchasing power, the mill operator releases his best attention to the more economical production of lumber.

As a result of these conditions, the modern tendency is towards central station electrification of sawmills. Many plants now use central station power entirely. Others use central station service in conjunction with their own power plants and as an auxiliary source. Sawmill executives are finding that their waste product can be sold for fuel purposes, which will pay for their purchased power expense. They realize a net saving of interest and maintenance on power plant investment, together with the saving of operating labor for these plants.

The earlier sawmills were designed for the purpose of converting logs of large dimensions into lumber. Due to the abundance and availability of timber stands of large size logs, little thought was given to the raw material represented by top logs and small size timber. With the passing of these large stands of available timber, the attention of the lumber industry is turning to the closer utilization of existing timber stands and to the growing of new timber crops. Greater utilization of existing timber stands depends upon the reduction of sawmill waste by more accurate saw-

ing methods, and the complete utilization of all trees cut. The use of reforesting tracts usually means the cutting of smaller sized timber and demands the complete use of all the logs cut.

Under existing schedules on the Pacific Coast, logs of less than 19 to 20 in. in diameter are not generally taken to the mills. Where clean cutting of timber is practiced, this not only results in the loss of a large percentage of marketable timber, but leaves a serious fire hazard. The sawing of small timber and top logs of minimum diameters varying between 8 in. and 20 in. would result in a greater utilization of from fifteen to twenty per cent of the timber cut.

There are still many mills using circular head saws of heavy gage which waste from 25 to 30 per cent of the timber in the form of sawdust. The use of band saws has distinct advantages for the sawing of certain types of logs. The inaccuracy of this method of cutting often requires the sizing of lumber to insure a uniform product. This operation represents a waste of timber and additional labor costs, amounting on an average to from 75c to $1.50 per thousand. On an average, the band and circular saws utilize not more than 50 per cent of the logs cut.

*Scandinavian Gang Saws—*

These conditions are now being appreciated by the lumber industry and there is a tendency toward improved design and cutting schedules for the new, or remodeled mills. An investigation of sawing conditions in Europe disclosed the fact that Scandinavian gang saws obtained a utilization of from 65 to 75 per cent of small logs, having an average top diameter of 6½ to 7 in. The operation of these saws was found so accurate and smooth that it was not necessary to size lumber in order to obtain uniformity of dimension. As a result of this report, an installation of these saws was made at the Tumwater Lumber Mills in Olympia and completed April 1, 1929. Data on this mill taken from the National Committee on "Wood Utilization" are appended to this report. In addition to the Olympia mill, there have been two other similar installations recently completed; one at the Clark-Nickerson plant in Everett, and the other at the new Peterson Bros. Lumber Company mill near Enumclaw, Wash.

The trend in lumber manufacturing outlined above, has had a decided effect on the factors involving electrification of these mills. The new conditions are outlined as follows:

1. Increased utilization of logs reduces the lumber waste and the amount of fuel available for power purposes.

2. In older mills the increased power requirements of this equipment are usually in excess of the existing generating capacity of the mill.

3. Transportation costs are such that new mills are often located near the supply of timber. This normally reduces the size of the mill and increases the proportionate investment and labor costs of a separate power plant.

4. These mills seldom require dry kilns since there is usually adequate space for air drying. Since boiler equipment is not needed for dry kilns, the total burden of boiler investment and operation must be carried by the power plant.

5. Smaller mills located near the timber supply usually have a shorter period of useful production. The investment in boiler and power plant equipment must be written off in a shorter time.

These factors combine to make electrification by central station power very attractive to the smaller mills and to those using the Scandinavian gang saw. This statement is sustained by the fact that the three initial Scandinavian gang saw installations are all electric driven by central station power.

*Conclusion—*

The advantages of electrical drive to lumber mill machinery have been definitely established in this industry. The use of central station power has previously been governed by local conditions. Modern tendencies in the lumber business are the utilization of lumber waste, reduction of lumber waste by better cutting schedules and a tendency toward smaller mills located near the timber stands. These factors have made central station power the economical solution to lumber mill electrification. This field now is a more accessible market for central station energy where surplus power is available and where this load is desirable to the central station.

## *Booth-Kelly Lumber Company Mill at Wendling, Ore.**

This mill, built in 1922, is an all electric mill powered by an individual plant located in the mill. Operations include a saw mill, planing mill and lath mill. Special motors were applied, so that they could be operated with direct drive, excepting a few drives, such as bandhead saws, gang saws and cut-off saws. All roll cases, transfer chain sections, conveyors, etc., were equipped with individual motors of such type that the operations of starting, stopping, reversing and jogging could be performed by the operator merely touching a push button. Frictions and belting, which are a great source of expense in the operation of sawmills, are practically eliminated in this mill.

The power plant at Wendling consists of:

1 1,000-kw. 2,300-volt condensing turbo-generator
1 600-kw. 2,300-volt condensing turbo-generator
1 100-kw. 2,300-volt non-condensing turbo-generator

All motors 50 hp. and above in the mill are 2,200 volts, while motors below 50 hp. are 440 volts. The low voltage for the 440-volt motors is obtained by means of transformers.

The result of the test which follows was obtained during the normal operation of this mill.

* Supplement No. 1 to report of power committee.

TABLE I.

| Department | Number of Motors | Total Hp. | Average Kw. | Average Daily Output: Total Board Ft. in M. | Average Daily Output: Total Kw.-hr. | Average Daily Output: Kw.-hr. per M. Ft. |
|---|---|---|---|---|---|---|
| Sawmill | 125 | 2,706½ | 860 | 198 | 6,683 | 34 |
| Planing mill including timber sizer and blower | 27 | 743 | 450 | 184 | 3,312 | 18 |
| Lath mill | 4 | 107½ | 40 | 30 | 320 | 11 |
| Miscellaneous | 5 | 79½ | 50 | ... | 800 | .. |
| Total | 161 | 3,636⅛ | 1,400 | ... | 11,115 | .. |

Average kw.-hr. per M ft. mill cut (includes sawmill, planing mill, lath mill, and miscellaneous) ..... 56
Average power factor ..... 0.70
Data on lath mill based on 1,000 lath.

## *Scandinavian Gang Saw Installation at Tumwater Lumber Mills Company, Olympia, Wash.**

This mill was completed in April, 1929, for the purpose of testing the Scandinavian gang saw as applied to American lumber production. The mill uses two

* Supplement No. 2 to report of power committee.

parallel gang saws with separate log hauls. The capacity of the mill is approximately 70,000 ft. per shift, using No. 3 grade of second growth Douglas fir.

*Gang Saws—*

The gang saw consists of parallel saw blades set in a frame, cutting several boards at one time from log stock by reciprocating saw motion. This gang differs from the American gang saw in that it is built for high speed cutting of small cants from round logs. Saws are hung at an angle and cut only on the down stroke, clearing the log on the up stroke.

The gang saws at the Olympia mill have a sash width of 26 in., stroke of 20 in. and an operating speed of 325 to 350 r.p.m. The driving pulley is 39½ in. in diameter with an 8½-in. base. This mill is using a 200-hp. motor for both saws, including log hauls, carriages and unloaders. The size of the main frame is 5½ ft. by 4½ ft. and the machine weighs approximately 21,000 lb. A very solid foundation is required in order to reduce vibration and insure accuracy of cutting.

*Operation—*

The Scandinavian system of gang-sawing lumber is based on the sorting of logs in the pond according to diameters. In the Olympia mill the logs are sorted in four diameters: 8 in. and less, 8 to 14 in., 14 to 18 in., and 18 in. and over. A definite sawing schedule is set up for each diameter class. The log hauls automatically stop the log on the jack, which is located to one side of the gang saw carriage. Under normal operation, the logs go through the saw in a continuous stream. Spacing of the saws varies with the stock desired; usually eight to twelve saws are used.

*Operating Crews—*

Due to the fact that sawing schedules are all prearranged for each diameter class of logs, skilled sawyers are not required.

The crew used on the Olympia mill is as follows:

| | |
|---|---|
| Pond men | 4 |
| Gang-saw operators | 4 |
| Filer | 1 |
| Edgerman | 1 |
| Edger spotters | 2 |
| Trimmermen | 2 |
| Sorting-table operators | 3 |
| Pacific Lumber Inspection Bureau inspector | 1 |
| Grader | 1 |
| Watchmen | 2 |
| Electrician and oiler | 1 |
| TOTAL | 22 |

*Output—*

The normal output of this mill is between 65,000 and 70,000 ft. per shift. Average cutting speeds for 15-in. top diameter logs were 16.7 log-ft. per minute; smaller logs are cut on an average of 18 log-ft. per minute.

*Manufacture—*

Very satisfactory results were obtained in uniformity of size and smoothness of cut. Sizing was not found necessary in this mill to insure uniform dimension and smooth surface. With proper planing equipment, less than 1/32-in. cut was necessary in comparison with ⅛-in. wastage on band-sawed lumber.

*Overrun—*

A test using logs of 8 to 19 in. diameter showed a 50 per cent to 55 per cent overrun using the Scribner log scale.

*Cost of Production—*

Labor costs including pond labor and loading for shipment are $2.00 to $2.25 per M.ft.

Miscellaneous expenses including power, supplies, etc., are $.50 to $.60 per M.ft.

*Power Requirements—*

Test data on the power requirements of this mill are as follows:

| | Kw.-Hr. | Kw. | Cut | Kw.-Hr. Per M |
|---|---|---|---|---|
| June 1930 | 54,400 | 320 | 1,723,843 | 31.7 |
| July 1930 | 48,800 | 304 | 1,602,916 | 30.4 |
| Aug. 1930 | 50,400 | 320 | 1,482,215 | 34.0 |
| Nov. 1930 | 52,800 | 344 | 1,606,000 | 32.9 |
| | 206,400 | | 6,414,974 | 32.1 |

*Cost of equipment—*

The cost of the equipment required is as follows:

| | |
|---|---|
| Two gang saws complete | $25,000 |
| Foundations | 2,000 |
| Installation | 800 |
| Motor | 800 |
| Total cost installed | $28,600 |

## *Commercial Cooking and Baking**

THIS committee during the past several years has discussed many phases of the commercial cooking and baking work. It has brought out the fact that this load is highly desirable for the power companies, with its excellent load factor, resulting in a high kw.-hr. use for each kilowatt connected. It is a load that has practically 100 per cent power factor. We know that a great amount of the potential load is located in the heart of the business districts where it can be connected to the companies' lines with a minimum of capital expenditure.

Commercial cooking is largely an off-peak load, both for the power company and the customer purchasing electric service. That is, most of the cooking and baking in commercial places is done during the early part of the day and does not affect the power company's daily peak load. For the customer, especially in large buildings and hotels where all current is billed through one meter, cooking and baking loads have been added where the increase in billing demand has not exceeded 30 per cent of the total load connected.

The sale of commercial cooking load is more competitive with other fuels than most of our electric sales are with other forms of energy. For this reason, the commercial cooking load must be persistently and aggressively sold. With this in mind, your committee has attempted to prepare a series of sales helps, pointing out the best methods that have been used by member companies to secure this load.

### Merchandising

Your committee believes that the securing of a commercial cooking and baking load for the power company is largely a merchandising job and that the best way to obtain this type of business is to employ men who primarily are salesmen and to train them for this work. This may be done, first, by contact with other

* Report of the commercial cooking and baking committee, power bureau, Commercial Section. Carl Hoffman, The Washington Water Power Company, chairman.
Edison General Electric Appliance Company: C. J. Anderson.
Idaho Power Company: O. C. Mayer.
Pacific Power & Light Company: L. R. Sheeley.
Puget Sound Power & Light Company: J. E. Dugan.
Utah Power & Light Company: George P. Trayner.

companies who are especially aggressive in promoting this load; second, by the attendance at schools, such as those conducted by the N.E.L.A.; and third, by the most important method of actual experience in the field, contacting the baker and restaurant operator.

Evidence that this load can be built up by a merchandising policy is demonstrated by the success of the Dohrmann Hotel Supply Company in a campaign which they conducted in April of 1930. This selling campaign, featuring Edison commercial cooking and baking appliances, was carried on in all their stores located in the principal cities of the Pacific Coast during one month in which a total of 582 pieces of equipment valued at about $90,000 was sold.

These appliances added to the lines of the Pacific Coast power companies a total of over 1,700 kw. with an estimated annual revenue of over $50,000. Approximately 25 per cent of this load was added in Seattle, Portland and Spokane. The men who made these sales were of the regular sales force of the Dohrmann company.

The above figures bring out the fact that the appliances sold averaged less than 3 kw. each, and that our volume in the business is to be the small commercial appliances, such as the coffee urn, waffle iron, griddle, etc. Each kilowatt of such appliances will use 1,500 to 2,000 kw.-hr. per year. Very often such small appliances are connected to the regular lighting meter, using current at a considerably higher price than with the large installations where the current is billed on a power or heating rate. Considerable mention is being made of these small appliances because of their revenue producing ability, and because so very often we overlook them in our efforts to sell complete electric kitchens and large oven installations, whereas a few small appliances, which are comparatively easy to sell, will return a revenue equal to one larger installation.

A further illustration of this point is brought out by the experience of one power company which sold 287 pieces of heavy duty merchandise during the past year, having a total connected load of 893 kw. Of this increase, 250 pieces of equipment account for 560 kw.—an average of 2.5 kw. per appliance. The remaining 333 kw. is absorbed by 28 larger pieces. This shows that these small load-building appliances can be sold while we are finding prospects for the larger appliances.

Customers should be contacted regularly by central station representatives because the central stations are in the manufacturing business to sell kw.-hr. much as the manufacturer of a commodity calls on his trade at regular intervals.

Many surveys have been made to determine how to build up this load, but your committee believes that the power company desiring this load should employ a sufficient number of salesmen adequately to take care of the prospects available. These salesmen should promote the sale of small commercial appliances, such as the waffle baker, toaster, griddle, fry kettle, etc. If this is done, the larger installations in hotel kitchens and traveling ovens will follow more or less in the natural course of events.

A report came to the committee that one of our member companies had lost about 25 per cent of its heavy duty appliance load during the past few years. This class of business is more competitive with other forms of energy than most of our business and it is necessary to keep in close touch with all users of commercial cooking and baking appliances, for you may be sure our competitors are always on the job. Possibly this loss of business could have been prevented if an effort had been made to keep these customers sold on electric cooking. This, then, again brings out the necessity of having salesmen make follow-up calls regularly.

### Advertising

In any commercial endeavor the correct advertising plan is essential. But, as we are appealing to only a limited number of people in specialized lines, general advertising is of no great value.

Your committee believes that a letter with some suitable advertising material should be sent to all the customers each month. The mailing list should be so classified that each customer will receive something of value to his particular business.

An advertising feature that has proved to be of considerable value is a cooking school or demonstration of heavy duty appliances. At such a demonstration, the various appliances should be connected and in operation. A competent cook, who is familiar with electric cooking, should be secured. Food should be prepared and served. It may surprise you to learn that the restaurant proprietor and his assistants derive a real pleasure from getting something to eat at such a demonstration. They are all curious to learn about electric cooking and many of those who are skeptical before seeing the equipment in operation, leave with the idea that it would be most desirable to use. The question usually arises, "Can I afford to cook electrically?"—and this is where the salesman really goes to work.

Demonstrations of heavy duty appliances to members of the sales department other than those who are actually doing this work, serve to stimulate interest in commercial heating appliances so they will keep their eyes open for prospects.

Advertisements by the manufacturers of electric cooking and baking equiment in the trade papers that reach the baker and restaurant man, serve to acquaint them with the many appliances on the market for their use. Very often these magazines will accept articles, with a good story about some new electric kitchen installation, for publication.

The men who follow this line of work should subscribe to the restaurant and bakery trade papers. In cities where there is a bakers' or caterers' association, the commercial cooking specialist should carry a membership. He should also secure a copy of the N.E.L.A. commercial cooking and baking sales manual, which you will find to be a very complete course in selling this class of load.

### Rates

The committee finds that the average net rate for commercial cooking is between 1¼ and 2 cents per kw.-hr. The fact that a company has a low rate does not necessarily indicate that it is in any better position to secure this business than the company with a higher rate. So many conditions enter into this, principally the cost of competitive fuels, that it may be easier to sell commercial cooking in the territory with the 2 cent rate, than in the territory with the 1¼ cent rate.

In the past, commercial cooking business was secured on the regular power rates of most of the companies. During the past two years, however, several companies of the Northwest have filed regular cooking and baking rates. These rates are not necessarily any lower than the existing power rates, but are designed to fit the characteristics of this load.

### Possibilities

According to figures prepared by the N.E.L.A., there is a possible load of 2,600 kw. for each 10,000

of population or about 1 kw. of commercial cooking and baking load for each residential consumer.

It was the intention of this report to show the percentage of the potential load that had been secured by the leading power companies of the Northwest. But upon receiving the reports from the various companies, the information differed so widely that it would be inaccurate to base our conclusions of the growth of commercial cooking and baking load on these data. Therefore, we can only point out the results that have been accomplished during the past year.

*Company No. 1, with 84,973 residential accounts:*

Employs three men full time and two men part time, who devote their efforts to the building of this load.

Results for the year of 1930 were as follows:

| | |
|---|---|
| Total amount of new load connected | 1773 kw. |
| Estimated revenue therefrom | $52,700 |
| Average net rate per kw.-hr. | 2 cents |
| Total number of new commercial cooking and baking appliances sold (estimated) | 600 pieces |
| Merchandise sales of heavy duty appliances | $44,500 |

*Company No. 2, with 52,183 residential accounts:*

Employs two men full time in commercial cooking and baking work:

Results for the year 1930 as follows:

| | |
|---|---|
| Total amount of new load connected | 893 kw. |
| Estimated revenue therefrom | $24,727 |
| Average net rate | 1.7 cents |
| Total number of new heavy duty appliances connected to lines | 287 pieces |
| Merchandise sales of heavy duty appliances | $16,100 |

These results are typical of what is being done and what could be done by other companies.

Whether or not the potential load in your territory is the same as pointed out above, it is at least a goal to work for. If your company can secure from one to two per cent of the potential load on this basis each year, we believe you will soon become enthusiastic supporters of the commercial cooking load.

It has been the intention of this report to point out the potential load that is awaiting development, and to bring to the attention of the members of this association, who are all agreed that it is a very desirable load, that every company, regardless of size, can develop a commercial cooking and baking load. A member of our committee pointed out that in these meetings for several years past, information has been furnished regarding every phase of the commercial cooking and baking load, and that at the present time there are only three companies in the Northwest association who are really active in this work. We understand that two more companies have added men to their sales force during the past year to specialize in this work.

We are sure the executives of the companies which have been most aggressive in this work are well pleased with the results and intend to continue to expand this department.

Your committee believes that every company should sell heavy duty appliances, as the best results have been obtained where central stations are actively merchandising heavy duty appliances. We should exert every possible influence in behalf of other dealers such as the hotel supply companies. The power company men should co-operate with the dealers even to the extent of sacrificing their own merchandising profit, for after all, the more we have co-operating with us, the more new business we receive.

In conclusion, we again wish to bring out these points:

1. That the commercial cooking load is obtained and developed by salesmen consistently promoting the use of this particular type of merchandise.
2. That a commercial cooking load can be developed by any company, as is evidenced by the success of the few companies who have consistently and aggressively gone after the business.
3. That, as it is primarily a merchandising job, if your company desires this business, it will have to go after it just as aggressively as it does after the domestic appliance load.

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## *Industrial Electric Heating**

THERE is no need to reiterate the desirable features of industrial electric heating, such as off-peak load, unity power factor, and higher revenue per kw. connected than motor loads. Neither are we going to recommend a survey to determine the possible field for electric heating, — suffice it to say that we do have a profitable market for electric heating, but one that is peculiar to our Northwest territory. Only time and a growing industry will bring in the large electrical installations such as we find in the East. Ours is a load consisting of many small and specialized applications. The very fact that we do not have many large installations has too often closed our eyes to the desirable smaller loads. A few of our member companies are actively working the smaller applications, with the result that hundreds of kw. are added yearly.

To try to define our field for electric heating would only tend to limit our vision and discourage the possibilities for growth in our Northwest section. We believe that wherever heat is used in industry, there lies our opportunity until proven otherwise. Only after a thorough investigation should a decision be made as to the most practical type of heating to be used. Many processes require specially designed equipment, which makes our product all the more valuable. It proves that electric heating is so flexible that it can meet almost any situation. We need more faith and a great deal more spirit of adventure in promoting the merits of electric heating. We must be better prepared as engineers to render accurate service in all details of application and designing. We must believe that, wherever heat is used, there lies a potential prospect.

No survey is of lasting importance because of the changing conditions in the processes of manufacturing. Better than a survey is a systematic visitation and follow-up program on all industrial accounts. Industrial electric heating literature of value should be placed in the hands of all our customers. A constant effort on the part of all heating engineers should be made to gain the confidence of our customers to the extent that, when they need advice on heating processes, they will immediately think in terms of our central station engineers.

*Knowledge of Competitors' Equipment Necessary—*

The work of our committee this year has been twofold. First, we have secured through the member companies the latest information on all new and novel electric heating installations and are passing this material on to member companies. Since our job is one

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* Report of the industrial electric heating committee, power bureau, Commercial Section. Asa K. Gaylord, Northwestern Electric Company, chairman.
Coates Electric Company: S. N. Coates.
General Electric Company: J. D. Frantz.
Portland General Electric Company: H. E. Bixby.
Puget Sound Power & Light Company: H. B. Batchellor.
Utah Power & Light Company: G. B. Walker.
The Washington Water Power Company: Edward F. Scofield.
Westinghouse Electric & Manufacturing Company: R. C. Cooper.

of small installations, we feel it advisable to spend a great deal of time in telling others of our many successful applications. Second, with the advent of keener competition from our oil and gas friends, we need to know more of their equipment. It has been true in the past that they have developed and marketed many a new product without the knowledge of the electrical industry. A permanent constructive job of competitive selling cannot be put over without a thorough knowledge of all types of equipment. It is poor business to permit our customers to receive information of gas and oil equipment from our competitors. We can make friends and sell more electric equipment by being able to dispose of competition by intelligently presenting the merits of all types of equipment. To this end all electric heating engineers should study publications covering these subjects.

As our competitors improve their products, our margin of selling points narrows down to the mere fundamentals of electric heating. That makes selling more of an engineering job. We should welcome this change, because we have the advantage when we meet our competitors on an engineering basis. We must be prepared to meet the severest conditions in competition.

Industrial electric heating has a future for power companies that bids well to surpass all other types of load now on our lines. We need no more surveys to determine the possibilities or the desirability of electric heating. We need to realize that only through a persistent constructive program of selling can we hope to get our share of this heating load. We should not wait until the field seems to be more promising, for, by doing so, our competitiors become more firmly entrenched in the established business in our territory. Hard work will be the answer for a successful industrial electric heating program.

# GENERAL BUREAU

## *Rural Electric Service**

THE national rural electric service committee, through its chairman, Eugene Holcomb, in a communication dated September 30, 1930, suggested to the divisional chairmen of rural service committees, that these committees should concentrate on load building on rural lines. The national committee suggested that we should endeavor to do this through the promotion of the sale of electrically operated equipment by working closely with merchandising committees. To this end it was suggested that the rural service committee have some membership or representation from the division merchandising committee. As Mr. Holcomb's letter to the chairman of this committee went astray, these suggestions were not received until after the organization of your committee.

The national committee suggested that the following topics be discussed by the division committees:

Selling equipment
Kinds of equipment
Approval of equipment
Company selling or dealer co-operation
How are prospects found
What to sell
Terms of payment
Compensation of salesmen
The kilowatt-hour basis for commissions

The national committee requested that division committees prepare a list of rural equipment that has been found successful in the division, and that this list include all significant specifications as to model, type, size, etc., descriptive of such equipment. The national committee requested that copy of this data be sent to Dr. E. A. White of the national C.R.E.A. Both of the above requests have been complied with, and a report was made at the conference of the Commercial Section, at Spokane, March 16-17, 1931, by different members of your committee, giving much of the information contained in the above report to the national committee.

The national committe has also emphasized the value of the state C.R.E.A.'s and advised that the divisional rural service committees support them in every way possible. It was felt that it would be of great help to have company executives attend the C.R.E.A. meetings.

*Rural Salesmen's Handbook—*

In line with our desire to co-operate with the national committee's program to concentrate on load building, we felt that one of the first things that should be done on such a program would be to provide rural service agents and salesmen with authentic information and data in a concentrated, well organized, and catalogued form. Well organized military units equip the soldier with adequate arms and ammunition before sending him into battle. Likewise, rural service men should be equally well equipped if they are to be successful in load building. Therefore, your committee feels that the best way to make a start along this line is to provide a rural electric service handbook for rural service salesmen and agents which will contain concise, authentic data well arranged in loose leaf book form.

It seems to the committee that the old rule "One thing at a time and that done well is as good a rule as one can tell," can very wisely be applied to the rural service committee of this division, at least for a few years. If the committee can and does prepare and publish a first class rural service handbook, we believe the committee will have fully justified its existence and that a material step forward will have been taken in the fundamental objective of building load on rural lines.

*Available Material—*

At least two of the geographic divisions of the N.E.L.A. have prepared such books. Both the Pacific Coast Electrical Association and the East Central division of the N.E.L.A. prepared and published in 1929 two very complete books, such as we have suggested that this division also publish.

Electrical manufacturing companies, such as the General Electric Company and the Westinghouse Electric and Manufacturing Company, have published books relative to the use of electricity on the farm, containing much information and data that would be appropriate for a handbook as above mentioned.

The various C.R.E.A.'s have also published similar books containing other data that would be of equal or greater value in such a handbook. Individual power companies have also published small books and pamph-

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* Report of the rural electric service committee, general bureau, Commercial Section. W. M. Hamilton, Portland General Electric Company, chairman.
The California Oregon Power Company: Thos. W. Delzell.
Idaho Power Company: R. S. Overstreet.
Mountain States Power Company: H. T. Gentry.
Northwestern Electric Company: F. H. Robinson.
Pacific Power & Light Company: D. B. Leonard.
Puget Sound Power & Light Company: J. H. Scott.
Utah Power & Light Company: P. H. Craven.
The Washington Water Power Company: Waldo W. Skuse.

lets giving much information and data of value to farmers.

From libraries formed by a collection of all of these various publications a very valuable handbook could no doubt be compiled for use in this division by our rural service men and others.

It is the consensus of opinion of the members of your committee that the Northwest association should compile a handbook of its own, rather than to buy copies of the other handbooks, which can be done at a very reasonable cost. It is felt that the conditions in the Northwest territory are at least somewhat, if not considerably different from the conditions in other geographic divisions, even different from those of the Pacific Coast division, and that a book should be compiled which would cover the conditions met with in this division.

### Cost of Handbook

As a guide as to the possible cost of such a handbook, we have the following information from the two associations mentioned who have already published handbooks:

#### Pacific Coast Electrical Association

| | |
|---|---|
| Original 200 copies cost | $ 670.00 |
| Additional 1,300 copies cost 35 cents each | 455.00 |
| Or 1,500 | $1,125.00 |

Average cost, each, 75 cents.
Cost of inserts to date, 20 cents.
Can furnish reasonable quantity of books with inserts at $1 each.

#### East Central Division

This division will furnish:

| | |
|---|---|
| 1,000 copies @ 67c | $ 670 |
| 1,500 copies @ 62c | 930 |
| 2,000 copies @ 58c | 1,160 |

This organization will permit us to use any part or all of its book, and the above quotations include the cost of printing the name of our association on and in the book wherever its name now appears.

We should bear in mind that our original book will cost us much less if we make use of as many of the sheets of the above two mentioned books of the other associations as we can. We should, therefore, endeavor to do so, even if such sheets do not quite meet our exact requirements. They can easily be replaced at a later date with a sheet more accurately meeting the conditions in this division. It appears, from a review of the other books, that many of their sheets can be used just as they are in our own book, as they do not bear the name of the association and it is not essential that the numbers of the pages be consecutive. The decimal system of subdivision can be used in case it is desired to insert other pages between pages of the other books that are already consecutively numbered.

All of this discussion is intended to indicate that the book as finally published will be the product of several factors, resulting in holding the cost of the original issue to an amount that the executive committee could approve, and which would come within the association's budget limitations. We must remember that such a handbook can, and will, no doubt, be enlarged and amended from year to year. Therefore, we may consistently economize on the original cost, in order to get the original edition of the book published and may later iron out its faults, and add needed data at a small cost per annum. Your committee will endeavor to ascertain from the member companies of the association how many copies of an association handbook for this division, as above recommended, each company would purchase for the use of its employees and others. With this data on hand, an estimate can be prepared of the cost of publishing such a book, and the necessary financial arrangements made through the executive committee of the association.

It is the idea of your present committee that additional data will be compiled, published and distributed by your subsequent rural service committees from year to year, thereby keeping the books up to date and as complete as possible.

A detail of the preparation and use of such book is that the leaves can, and no doubt will be punched for a standard ring type of loose leaf binder. Persons who wish to carry the handbook around and who therefore need a cover more substantial than the ordinary paper cover may purchase a leather ring binder and keep in this binder as many of the handbook leaves as they may

ELECTRIC LIGHT & POWER INDUSTRY
PRELIMINARY ESTIMATE OF NUMBER OF FARMS SERVED FOR 1930.*

| | Number of Farms Served | | | | |
|---|---|---|---|---|---|
| | On Dec. 31, 1930 | On Dec. 31, 1929 | On Dec. 31, 1928 | Farms added during 1930 | % Increase |
| Total United States | 647,677 | 556,871 | 460,969 | 90,806 | +16.3 |
| Maine | 16,100 | 14,750 | 11,878 | 1,350 | + 9.2 |
| New Hampshire | 6,945 | 6,273 | 3,503 | 672 | +10.7 |
| Vermont | 3,233 | 2,810 | 2,414 | 423 | +15.1 |
| Massachusetts | 12,916 | 12,353 | 11,097 | 563 | + 4.6 |
| Rhode Island | 855 | 839 | 755 | 16 | + 1.9 |
| Connecticut | 4,664 | 4,464 | 4,141 | 200 | + 4.5 |
| Total New England | 44,713 | 41,489 | 33,788 | 3,224 | + 7.8 |
| New York | 61,086 | 53,060 | 47,800 | 8,026 | +15.1 |
| New Jersey | 9,807 | 9,526 | 8,944 | 281 | + 2.9 |
| Pennsylvania | 40,902 | 33,335 | 27,105 | 7,567 | +22.7 |
| Total Middle Atlantic | 111,795 | 95,921 | 83,849 | 15,874 | +16.5 |
| Ohio | 45,767 | 38,045 | 30,575 | 7,722 | +20.3 |
| Indiana | 20,523 | 17,983 | 15,163 | 2,540 | +14.1 |
| Illinois | 20,956 | 16,854 | 13,494 | 4,102 | +24.3 |
| Michigan | 27,533 | 22,293 | 18,200 | 5,240 | +23.5 |
| Wisconsin | 36,181 | 30,177 | 22,700 | 6,004 | +19.9 |
| Total East No. Central | 150,960 | 125,352 | 100,132 | 25,608 | +20.4 |
| Minnesota | 12,772 | 11,252 | 10,500 | 1,520 | +13.5 |
| Iowa | 21,947 | 17,947 | 13,817 | 4,000 | +22.3 |
| Missouri | 11,147 | 9,129 | 7,007 | 2,018 | +22.1 |
| North Dakota | 560 | 518 | 506 | 42 | + 8.1 |
| South Dakota | 1,682 | 1,484 | 1,242 | 198 | +13.3 |
| Nebraska | 7,867 | 6,537 | 4,047 | 1,330 | +20.3 |
| Kansas | 8,672 | 7,552 | 5,331 | 1,120 | +14.8 |
| Total West No. Central | 64,647 | 54,419 | 42,450 | 10,228 | +18.8 |
| Delaware | 1,056 | 922 | 700 | 134 | +14.5 |
| Maryland & D. of C. | 10,660 | 9,635 | 8,217 | 1,025 | +10.6 |
| Virginia | 12,642 | 10,236 | 7,680 | 2,406 | +23.5 |
| West Virginia | 6,355 | 5,845 | 4,525 | 510 | + 8.7 |
| North Carolina | 6,823 | 5,940 | 5,250 | 883 | +14.9 |
| South Carolina | 1,769 | 1,723 | 1,178 | 46 | + 2.7 |
| Georgia | 5,844 | 4,129 | 3,941 | 1,215 | +29.4 |
| Florida | 3,647 | 3,386 | 2,781 | 261 | + 7.7 |
| Total South Atlantic | 48,296 | 41,816 | 34,272 | 6,480 | +15.5 |
| Kentucky | 8,915 | 7,225 | 5,700 | 1,690 | +23.4 |
| Tennessee | 2,630 | 1,578 | 1,218 | 1,052 | +66.7 |
| Alamaba | 11,289 | 8,062 | 6,632 | 3,227 | +40.0 |
| Mississippi | 3,470 | 1,964 | 1,356 | 1,506 | +76.7 |
| Total East So. Central | 26,304 | 18,829 | 14,906 | 7,475 | +39.7 |
| Arkansas | 2,454 | 1,609 | 1,217 | 845 | +52.5 |
| Louisiana | 2,854 | 2,440 | 1,904 | 414 | +17.0 |
| Oklahoma | 4,192 | 3,303 | 2,668 | 889 | +26.9 |
| Texas | 8,617 | 7,021 | 5,785 | 1,596 | +22.7 |
| Total West So. Central | 18,117 | 14,373 | 11,574 | 3,744 | +26.0 |
| Montana | 2,058 | 1,844 | 890 | 214 | +11.6 |
| Idaho | 13,162 | 11,754 | 9,157 | 1,408 | +12.0 |
| Wyoming | 556 | 532 | 388 | 24 | + 4.5 |
| Colorado | 8,419 | 8,079 | 6,670 | 340 | + 4.2 |
| New Mexico | 1,127 | 1,079 | 923 | 48 | + 4.4 |
| Arizona | 4,800 | 3,989 | 2,065 | 811 | +20.3 |
| Utah | 12,180 | 11,730 | 10,114 | 450 | + 3.8 |
| Nevada | 1,614 | 1,360 | 1,200 | 254 | +18.7 |
| Total Mountain | 43,916 | 40,367 | 31,407 | 3,549 | + 8.8 |
| Washington | 41,653 | 37,813 | 34,443 | 3,840 | +10.2 |
| Oregon | 16,026 | 13,802 | 11,428 | 2,224 | +16.1 |
| California | 81,250 | 72,690 | 62,720 | 8,560 | +11.8 |
| Total Pacific | 138,929 | 124,305 | 108,591 | 14,624 | +11.8 |

Subject to revision on completion of summary of annual reports and survey of rural electric service committee.
*Supplement No. 1 to report of rural electric service committee.

wish to carry around, and the balance of the leaves can be kept stapled together in paper covered volumes in the office. These leaves will then be readily transferable to the ring binder, or vice versa, as the occasion many demand.

### Rural Short Courses

Before closing this report, attention should be called to the rural electric short course classes held by the University of Idaho on Jan. 19 to 23, inclusive, of this year at Moscow, Idaho; the school for rural electric service men held by the Oregon State Agricultural College from Jan. 26 to 30, inclusive; and the rural electric short course held by the State College of Washington at Pullman from March 3 to 5, inclusive.

Reports of the attendance at these schools indicate the high regard for these schools held by the industry and the evident value of these schools and classes to persons engaged in, or interested in rural electrification. Such schools undoubtedly fill a need in the dissemination of information relative to rural electrification that cannot be filled otherwise. It is to be hoped that these schools will be continued and that the programs will continue to be as excellent as they have been heretofore.

The chairman of your committee received recently from the chairman of the national committee, a communication inclosing a preliminary estimate of the number of farms served for 1930 for each state, as made by the statistical research department of the N.E.L.A.

N.E.L.A. headquarters has asked Mr. Holcomb to have divisional rural service committees check the above mentioned figures as closely as possible. We take this opportunity to advise the various companies of this geographic division that we will seek their cooperation in an effort to comply with the request of N.E.L.A. headquarters, as above outlined, so that we may forward this information to N.E.L.A. headquarters as soon as possible.

Attached to this report is a copy of the above mentioned preliminary estimate of the number of farms served for 1930.

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## *Selling Wiring to the Farm**

THE work of the wiring sales committee, as laid out by the N.E.L.A. is as follows: To develop methods of wiring; to study, develop and test wiring materials, flexible cords, etc.; to stress market possibilities for better wiring in the home; to study codes and standardization relating to wiring and advise with the code and standards committee; to promote directly, or in conjunction with appliance sales, activities directed towards adequate wiring installations.

The foregoing outline of the work assigned to this committee covers some territory that it seems might safely be left with the code committee. The desirability of stressing market possibilities for better wiring in the home seems, to your committee, to be the particular part of the above assignment that it feels most competent to undertake.

The problem of selling more adequate wiring in the home should be divided into two divisions: first, the wiring of residences in cities and nearby suburban homes; and second, the wiring of farm homes, barns, chicken houses, milk houses and barn yards.

Regarding the first problem, your committee feels that this subject has been quite thoroughly covered in former reports and that most companies have carried on and still are carrying on the necessary educational work. The results of campaigns along this line show the desirability of continuing this work.

### Results Anticipated

The second problem, namely, the adequate wiring of rural homes, has received considerable thought in the past, and numerous pamphlets on the subject have been printed, but your committee believes the possibilities are still great. Unquestionably the greatest possibility for the expansion of the electrical industry lies with the proper electrification of the farm. In the early days of home lighting, drop lights were swung from the ceiling and practically no provision was made for the use of appliances. The wiring in many of the farms today is in a somewhat similar condition, and an organized educational program for the better wiring of the farm will amply repay the utility companies in opening the way for more complete electrification.

Numerous publications devoted to electrical installations on the farm are now available, but some of these, while very good, are too expensive for widespread free distribution, such as could be had with an inexpensive folder which, we believe, should arouse sufficient interest to justify its limited expense. This folder should be so written that the farmer could easily understand the recommendations it contains, and it should be so worded that the farmer would grasp that the company was actually trying to help him solve his problems and was not merely trying to sell him merchandise.

### Suggested Type of Printed Folder

After careful consideration, your committee is herewith submitting a folder that it believes will fit the above conditions. In this folder the farmer is urged to consider a comprehensive plan for utilizing electric service, and to install each portion of his wiring with sufficient capacity so that it can be added to without overloading his main circuits, thereby necessitating the scrapping of a part of his original installation.

The object of this folder is not to be a specific guide as to how the wiring should be installed, but to sell the farmer on the desirability of so wiring his premises that the full use of electric service will be available. Throughout the pamphlet his attention is called to the fact that the utility company is offering, without cost to him, the services of trained engineers and agriculturists to aid him in working out his electrical problems. The wide distribution of this type of folder through the channels of metermen, service-men, meter-readers and others who contact the rural customers would, it seems to us, be the opening wedge in arousing interest in better and more adequate wiring installations. The principal object is to create sufficient interest to cause the farmer to ask us for assistance, as it has been proved that information and help asked for is more readily accepted and acted upon than where it is thrust upon the customer before he is in the proper frame of mind to receive it. The cost of printing the pamphlet suggested is approximately 1½ cents apiece, and we believe it will be as readily accepted by the customer as was the pamphlet submitted by your committee last year and which has been used very extensively by some companies.

The pamphlet displayed herewith, as illustrative of

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* Report of the wiring sales committee, general bureau, Commercial Section. F. H. Kerr, Puget Sound Power & Light Company, chairman.
Portland General Electric Company: W. D. Williams.
Puget Sound Power & Light Company: Henry Kruze.
Utah Power & Light Company: W. M. Scott.
The Washington Water Power Company: Ladner V. Ross.

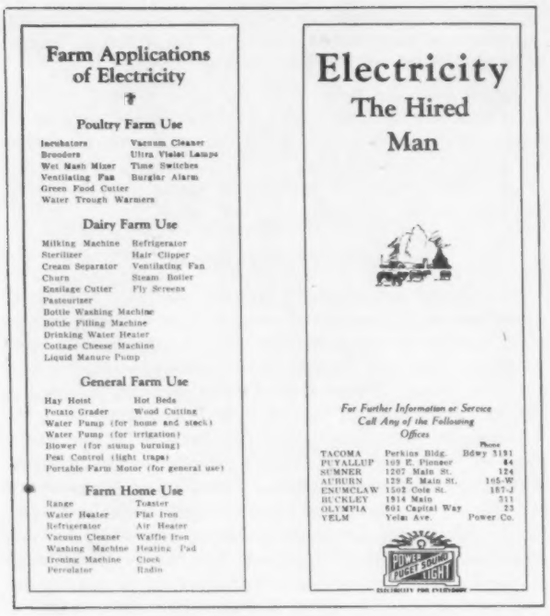


*Fig. 1. Front and back cover of folder on farm wiring published by one of the member companies.*

the kind of pamphlet suggested in the foregoing, has recently been produced and put into use by one of the member companies.

## Appendix I. Text of Farm Wiring Pamphlet as Used by One of the Member Companies

### Electricity—The Hired Man

The farmer's problems, in many ways, are similar to those of the manufacturer. He has his fixed costs, such as invested capital, taxes, insurance, etc., and these must be met regardless of the market prices of his products. The manufacturer has largely solved his problem by the introduction of labor saving machinery and with it, mass production. Practically all the new machines that have been placed in the factories in recent years are electrically driven and many are automatic in their operation. The farm is the farmer's factory, and his problem is to lower his cost of present production or produce more without increasing his present cost. In either event electricity on the farm will aid him. Considerable time is spent each day by the farmer and his wife doing the chores by manual labor when much of this time and effort could be saved by using a small electric motor or other electric equipment, at a cost of a cent or two an hour. Adequate electric equipment would also help to solve many of his employment problems.

It is the idea of this folder to suggest the numerous applications of electrical apparatus that will help the farmer, and to give a general plan of the wiring that should be installed. As the specific wiring plan will vary with each farm, the company suggests that its trained agriculturist, whose services will be furnished without charge, be called in to help plan the installation. Such planning will undoubtedly effect a saving in cost to the farmer, as he will be able to profit by the experience of other installations.

The electric wiring on the farm should be designed to furnish service to the barn, milk-house, pump-house, poultry-house and to such other locations as the farmer may desire, and last but not least, the home.

### Main Point of Service

The main point of service should provide a suitable location for the main line switch and meter and should be so located that the various places for use of the electric service can be reached with the minimum amount of wiring. Where the largest motor will not exceed 5 hp., a three-wire 110 to 220-volt service will be ample.

### The Barn

Three wires should be run to the barn so that power will be available as well as lighting. The main wires should first run to safety switches or to properly fused equipment in a steel cabinet, and from there to the various points of intended use of service. The wires should be run in a substantial manner, thoroughly protected from mechanical injury.

The lighting of the barn should be laid out so as to give good illumination throughout the building, and should be controlled by switches located at the several points where they will be the most convenient. The cost of operation of the lights will be less if they are properly grouped for control by switches that are well located.

The power circuit should be so installed that convenience outlets will be available for the use of portable machines as well as the services to permanent machines. A liberal supply of outlets will make the use of long extension cords unnecessary, and the additional cost will be slight. Weatherproof outlets should be installed on the outside of the barn, thus providing motor connections for ensilage cutting and wood sawing and an outlet for a water heater to be used in the watering trough.

Our experienced agriculturist will be of material assistance here, as he is thoroughly familiar with these machines, as well as with the several types and makes of milking machines.

### The Milk House

The wiring to this building should be three-wire as it will then furnish 110-volt service for the lighting and small motors on the cream separator, bottle washer, and bottle-filling machine, and 220-volt service for the medium or large size sterilizer and ice machine. The wiring in this building should be protected by safety switches or properly fused equipment installed in a steel cabinet. Here again the trained agriculturist will be of service to the farmer.

### The Pump House

This service should be either two or three-wire, depending upon the size of the pump motor, and should be protected by properly fused equipment.

### Poultry House

The modern poultry farm has been developed to a high degree of efficiency, and electricity has played a leading part in this development. The wiring of the various departments of this plant should be carefully laid out by a man with experience in this line of work. The main service for the plant should be three-wire, 110 to 220-volt, with safety switches or properly fused equipment in a steel cabinet. The feed room should have a 220-volt service for the motor operating the feed cutter or similar equipment, as well as 110-volt circuit for the lights. A special three-wire circuit should be run in the laying house for the bright and dim lights controlled by two manually operated switches or by an automatic time switch. Chrome plated or aluminum shades must be used if the new CX ultra violet type of lamp is used to prolong the daylight hours. A separate circuit should be wired and convenience outlets placed for the use of the water trough heaters, ventilating fans and sprayers that are used for disinfecting, painting, or white washing. This circuit should be independent of the lighting circuit, as this service should be available at all times and should have sufficient capacity to handle the various loads that will be placed upon it. The brooder and incubator departments should be wired with 110 to 220-volt three-wire service of sufficient capacity to give good voltage regulation. A battery alarm system should be installed to give an alarm in case of low temperature or power interruption. These rooms should be well lighted and the control switches should be conveniently located. The power circuit should have the necessary outlets for the incubator, brooder, vacuum cleaner (used for removing the "chicken down" from the incubator), for the ventilating fan and for extension cords that are used for inspection lights and candling lights. Provision should be made in the brooder room for the use of the new CX ultra violet lamps and these should hang about three feet above the feeding troughs.

### The Farm Yard

The farm yard should be well lighted by one or more lights, depending upon the space to be illuminated. A goose-neck pipe fixture with a white metal shade may be placed on a pole, conveniently located in the yard, and also on the front of the barn, with the switch control on the back porch of the house. If desirable, the yard lighting can be controlled from two independent points by the use of special switches and wiring. It may also be desirable to have a power outlet on the lighting pole where a motor, used for wood sawing or other utilitarian purposes, could be connected.

### The Home

The house is the workshop of the wife. It is just as important that efficienecy in the operation of her work be considered as it is for the rest of the farm. A large portion of her time is spent in the kitchen.

an providing for the wiring of the kitchen, 220-volt, three-wire service should be run to a convenient location for the use of an electric range. Power circuits of 110 volts should be run to a convenient location for ironing, also to a location near her work table for the use of a food-grinding machine or food-mixer. A circuit should also be provided for an electric refrigerator. Near the breakfast table a 110-volt power circuit should be provided for the use of a percolator, waffle iron and toaster. If there is not a laundry room in the house, a 110-volt power outlet should be placed either in the kitchen or on the back porch in a convenient location for the washing machine. The back porch should be lighted and this light should be controlled by a switch placed near the back door in the kitchen. The kitchen should be lighted by a kitchen unit ceiling fixture operated by a wall switch placed by the outside door, or by two switches, one by the outside door and one placed by the door leading into the rest of the house. These switches should operate independently.

If the hot water tank is located in the kitchen, a 110 to 220-volt outlet should be provided for an electric water heater. If the tank is located elsewhere in the house, this provision should be made where the tank is located.

The dining room should be lighted by a center fixture placed over the dining room table and controlled by a wall switch conveniently located near the kitchen door. Auxiliary lighting may be had by bracket wall lights, if desired. Convenience power outlets should be placed on 110-volt circuits at locations in the dining room for the use of the vacuum cleaner and the small table appliances, such as toaster, percolator, waffle iron and others. In some cases, the housewife may find it desirable to have an outlet placed in the floor beneath the dining room table for the connection of the table appliances so that the cords will not extend into the room, where they may be tripped over.

The living room should be provided with a center lighting fixture, controlled by a wall switch placed near the front door. It is also advisable to have an independently operated switch for this fixture placed near the door most frequently used in entering the living room from the rest of the house. Double convenience outlets should be placed in the side walls, at frequent intervals, around the room for the connection of floor lamps, table lamps, auxiliary air heaters, the radio and vacuum cleaner. Side wall lighting fixtures and auxiliary lighting may be installed in convenient locations if desired. These can either be operated by switches within the fixture, which can be easily reached or can be grouped so that they can be operated by one switch placed in the most convenient point of entrance to the room.

The front porch should be provided with a ceiling fixture controlled by a switch inside the front door, and a double convenience wall outlet should be placed in a convenient location on the front porch to provide for outdoor illumination such as tree and shrubbery lighting or festoon lighting.

The bedroom should be equipped for at least one center lighting fixture to be controlled by a wall switch near the door. Auxiliary lighting in the way of wall brackets may be placed on each side of the bureau or dressing table if desired. These can either be operated from a switch in the fixture or from a switch placed near the door. Double convenience outlets should be placed in the side walls near the bed for lamps and the use of an electric heating pad, and in other locations in the room where most convenient for the use of an auxiliary air heater and the vacuum cleaner.

In wiring the bathroom, it is well to provide for one center fixture of the ceiling type, controlled by a wall switch near the door. It is also recommended that a bracket light be installed on either sire of the mirror. These fixtures can be operated by a switch in each fixture. A double convenience outlet should be placed in the side wall near the mirror for the use of an auxiliary air heater and other small electric appliances such as the health motor, sun lamp, hand vibrator, small immersion water heater, etc.

The basement of the house should be wired so that a light at the foot of the stairs may be operated from a switch placed at the door of the entrance. Other lights should be arranged for in the basement at convenint locations, such as in front of the furnace, over the laundry trays, in front of the fruit closet, etc. A 110-volt power circuit should be provided near the furnace for the fuel stoker or oil burner. A similar circuit should be provided near the laundry trays for the washing machine.

### Conclusion

It is recommended that the customer take advantage of the company's offer to furnish a competent man to help plan the installation without charge to the customer. The plan itself should include all the necessary services for the numerous points of use but the customer may, for his own reasons, wish to make but a partial installation at first. Should this be the case, the proper comprehensive plan would avoid the waste that might be encountered by the installation of inadequate wiring on the original service. It is also recommended that the wiring be done by a competent licensed electrician, which will prove to be an economy in the long run.

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## *Effect of Promotional Rates on Residential Service**

THE work of the committee was confined to a study of residential service and the report will consist largely of a discussion of a set of eight curve sheets showing the average results obtained from this class of service by companies in association territory. These curve sheets indicate the present status of residential service from various angles and are offered with the thought that the forms themselves may contain suggestions that may be useful to the various companies in further analysis of their own operations.

The committee is of the opinion that the two main factors tending to bring about the desired result in residential service, namely, increased kw.-hr. consumption per residential consumer, are promotional or inducement rates and merchandising activities. It is due only to the close connection between these two factors as affecting residential service that the committee has included a brief study of merchandising activities.

So far as promotional or inducement rates are concerned, the committee has confined its activities to a study of combination rates for residential service covering lighting, small appliances, electric ranges, refrigerators and electric water heaters, where all such service is taken through one meter.

### Load Characteristics

The first undertaking of the committee was a study of the load characteristics of each appliance and a combination of the various appliances mentioned above, toward the end of obtaining an idea as to the load factor that might be expected for a combination of all appliances. It was thought that the load factor of the combined service would be reasonably high and that this might form the most reasonable support for offering in a combination rate, a comparatively low average rate per kw.-hr.

Figs. 1 and 2 show the results of this study and cover 65 typical installations. Fig. 1 shows the results obtained from service to electric ranges and electric water heaters and a combination of these two services. Fig. 2 covers service to lighting and small appliances and electric refrigerators, with a combined curve covering all four classes of service.

The information forming the basis of these curves was obtained from various sources. That covering lighting and small appliances and electric ranges was taken from a study made by the Northwest association in Spokane, and that covering electric refrigerators and electric water heaters was based on recent studies made in Salt Lake City.

These load curves cover typical service for a period of seven days and were arrived at by adding the individual loads of 65 separate installations to form a composite load curve for this number of installations, so that whatever diversity existed between the individual installations is taken into account in the total load curve shown in Fig. 2.

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* Report of the promotional rates committee. R. H. Ashworth, Utah Power & Light Company, chairman.
Idaho Power Company: K. M. Robinson.
Montana Power Company: H. H. Cochrane.
Puget Sound Power & Light Company: L. R. Grant.

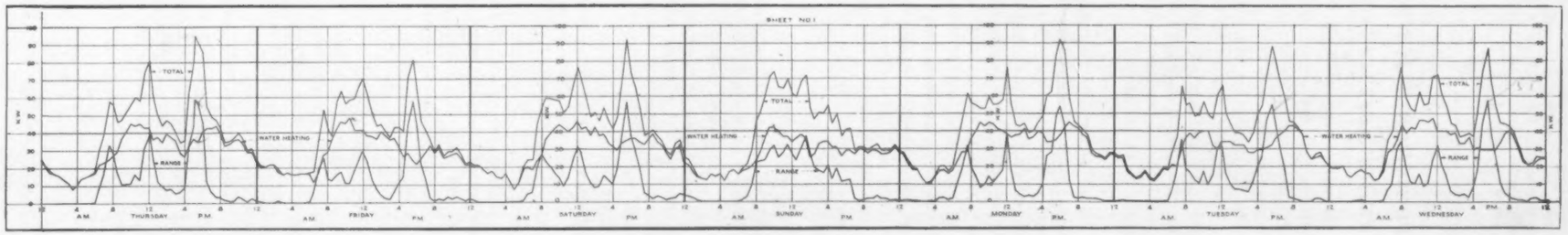


*Fig. 1. Load curves for 65 installations of the following units: A. Ranges. B. Water heating.*

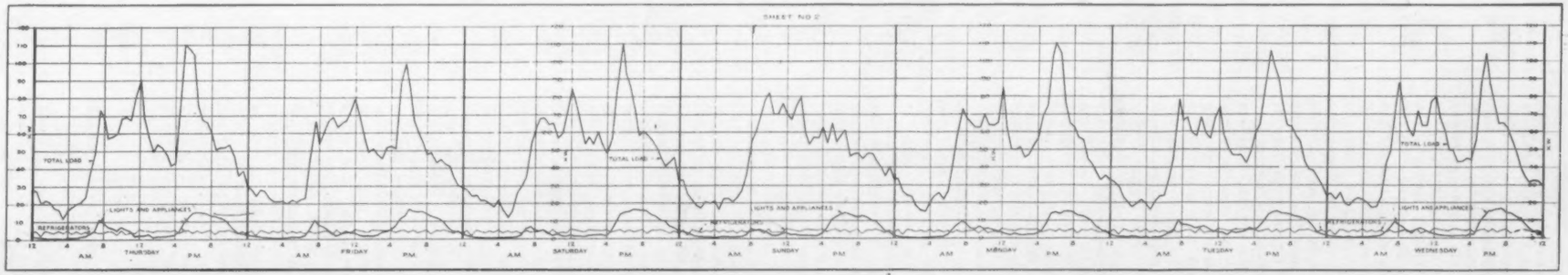


*Fig. 2. Load curves for 65 installations of the following units: A. Lights and appliances. B. Ranges. C. Electric refrigerators. D. Water heaters.*

| *Load factors for typical week* | *Per cent* |
|---|---|
| *1. Lights and appliances* | *30.9* |
| *2. Lights, appliances and refrigerators* | *44.5* |
| *3. Lights, appliances and ranges* | *22.7* |
| *4. Lights, appliances, ranges and refrigerators* | *26.8* |
| *5. Lights, appliances, ranges and water heaters* | *42.4* |
| *6. Lights, appliances, ranges, refrigerators and water heaters* | *44.8* |

The load factors shown at the right hand side of Fig. 2 for various combinations of domestic service should prove of considerable interest, and it should be noted that for a group of residential consumers, using all the major appliances, the composite load factor arrived at is 44.8 per cent.

### Combination Rates

The residential rates of the various companies were secured and studied, and it was found that practically all companies are offering a promotional or inducement type of rate in the form of a combination rate covering service for all the major domestic appliances through one meter. There was, however, found to be a considerable difference in the type of these rates, with not a great deal of difference, however, in the net result as shown by the average rate per kw.-hr. and the net monthly bill for various consumptions.

Some companies are using the number of rooms as the basis of the rate; others are using the floor area, while others carry a flat charge regardless of the number of rooms. Each of the above types of rate provides a comparatively low kw.-hr. charge. A number of the companies, on the other hand, are using a straight block kw.-hr. rate. There seems, however, to be a general tendency toward the adoption of a combination rate consisting of a flat charge based on the number of rooms, followed by comparatively low kw.-hr. charges consisting of from one to three steps, with, in the majority of cases, a bottom step of not less than 1½ cents per kw.-hr.

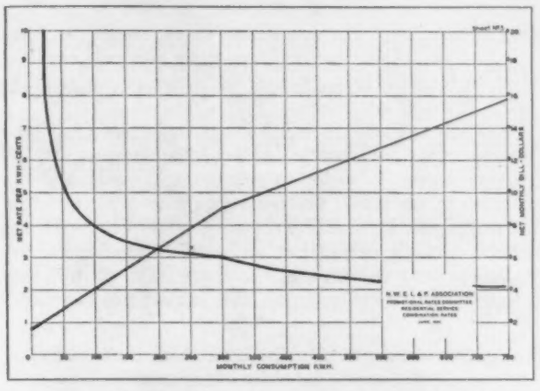

*Fig. 3. Residential service combination rates—1931.*

Fig. 3 shows, for a monthly consumption up to 750 kw.-hr., the net rate per kw.-hr. and net monthly bill under a typical combination rate consisting of a flat charge based on the number of rooms, followed by low kw.-hr. charges, first for a block of kw.-hr. to cover lighting and appliances including electric range service, but not including water heating, and second, with a bottom step of 1½ cents per kw.-hr. to cover water heating where all service including water heating is taken through one meter.

In connection with rates for water heating, some companies are offering one combination rate to cover all service, while others are offering a combination rate to include all domestic appliances except water heating and then handle this service through a separate meter at a low rate per kw.-hr. or on a flat rate basis.

It is interesting to note that, in connection with combination rates offered, there is no rate being offered at the present time which carries a prompt payment discount. The rates of the majority of the companies are simply stated as a net rate, but there are a few companies which add a certain amount to the net bill in order to determine the gross bill, as a stimulus toward the prompt payment of bills.

### Accomplishments

The following four curve sheets, Figs. 4 to 7 inclusive, show the average of the results obtained by all companies from residential service for a period of five years, 1925 to 1930 inclusive. All residential consumers are included, whether they are using lighting and small appliances only, or one or more of the major appliances in addition.

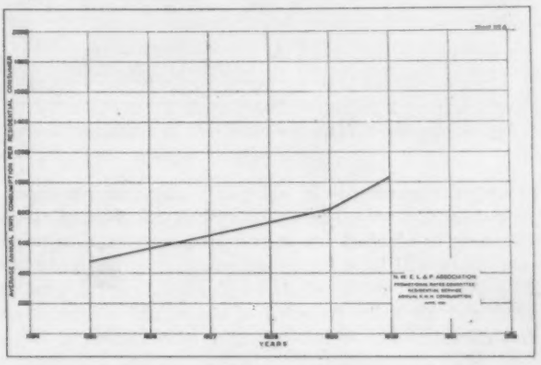

*Fig. 4. Annual kilowatt-hour consumption.*

Fig. 4 shows the average annual consumption per residential consumer. It is of interest to note that the consumption per consumer has more than doubled during the last five years, and for the year 1930 averaged slightly in excess of 1,000 kw.-hr. The trend was practically uniform for the first four years of the period covered, but there was a decided additional increase for the year 1930. This is probably due principally to the material increase in merchandise sales for the years 1928 and 1929, shown on Fig. 7, the effect of which would not be fully reflected until the 1930 consumption.

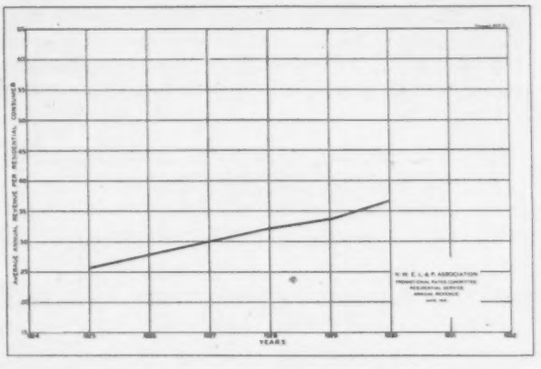

*Fig. 5. Residential service-annual revenue. June, 1931.*

Fig. 5 shows the average annual revenue per domestic consumer, and indicates that the revenue has increased on a practically uniform basis each year, to the extent of approximately $11 per consumer during the five-year period, reaching nearly $37 by 1930.

Fig. 6 shows the average rate per kw.-hr., and indicates that the average rate has decreased during the five-year period approximately 2 cents per kw.-hr., with an average rate for the year 1930 of approximately 3½ cents.

Fig. 7 shows the average merchandise sales per residential consumer. This curve shows little increase for the first two years covered, but a marked increase for the years 1928 and 1929 and a slight decrease for the year 1930. The merchandise sales for the year 1930

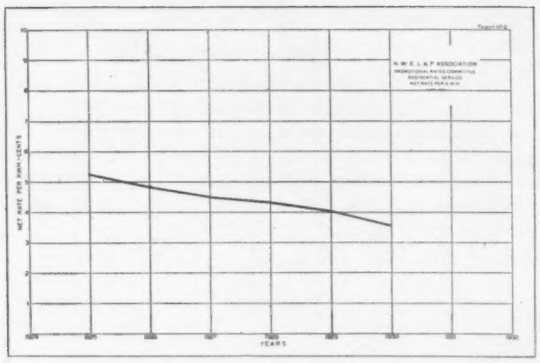

*Fig. 6. Residential service—net rate per kilowatt-hour.*

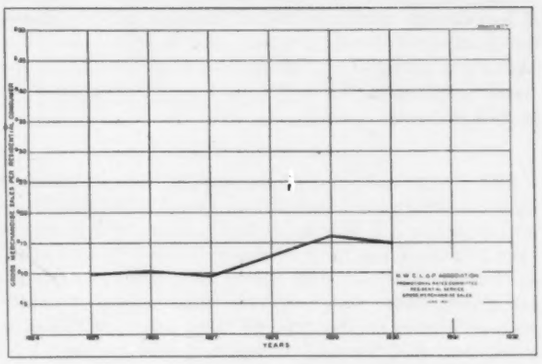

*Fig. 7. Residential service—gross merchandise sales.*

averaged approximately $15 per residential consumer. In connection with the study of merchandise sales as affecting residential service, it should be kept in mind that there will be a lag of approximately one year before the effect of merchandise sales in any particular year will be fully reflected in increased consumption and revenue. The study covering merchandising sales probably has no direct part in the work of the promotional rates committee, but the brief study given was considered advisable due to the close relationship between this activity and promotional rates as affecting kw.-hr. consumption.

### Study of Results

Fig. 8 is probably the most interesting sheet of the set. It shows graphically the combined results obtained from residential service, including the average rate per kw.-hr., the average consumption and the revenue per consumer.

If it is taken for granted that the main object to be accomplished in making rates for residential service is increased average annual consumption, possibly this can be done only with a resulting decrease in the average rate per kw.-hr. If, on the other hand, the average rate per kw.-hr., as indicated by this curve sheet, decreases with increased consumption to such an extent that there is little, if any, resulting increase in revenue, such an increase in consumption is, of course, of little material value. Results along this line can be studied very closely by the use of this sheet. The sheet is also offered with the thought that it may prove useful as a suggestion to any particular company of a way of establishing a definite record of past performance and to serve as a guide in connection with contemplated changes in residential rates.

### Conclusion

The committee has no particular or definite recommendations to make at this time, in view of the fact that practically all companies seem either to have adopted or to be working toward a general combination residential rate, where all such service may be taken through one meter.

There is one matter that has not been given any particular study and seems to the committee to deserve further study. In order to stimulate the sale and use of more of the major residential appliances, practically all companies have offered a residential rate with the kw.-hr. charge decreasing as various appliances are added, so that the resultant average rate, particularly where a consumer uses all the major appliances, is

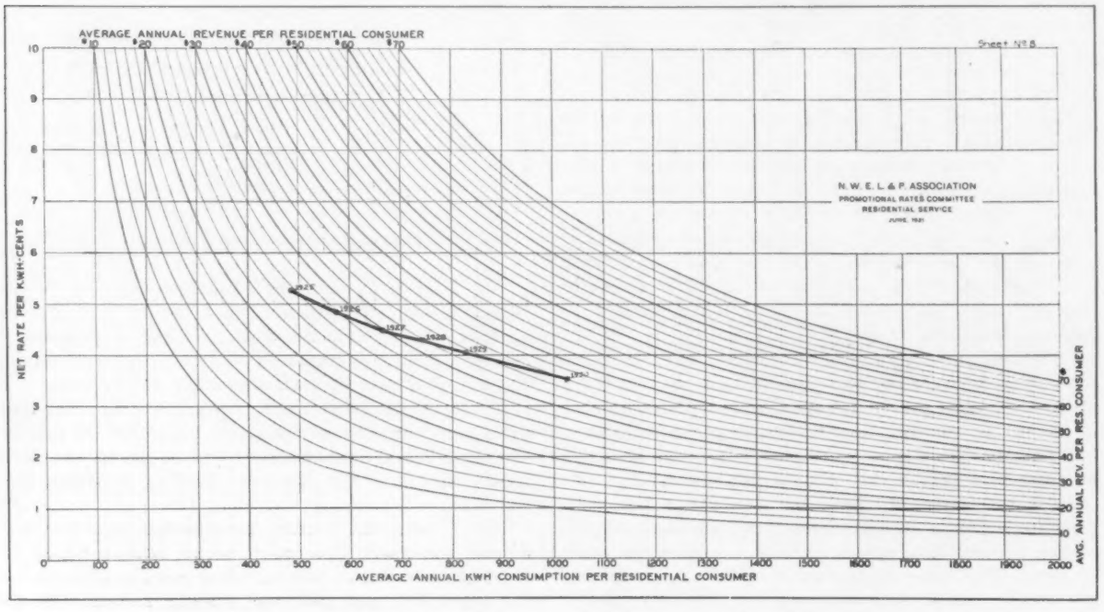


*Fig. 8. Average annual kilowatt-hour consumption per residential consumer.*

comparatively low. As a result of this fact, apparently some criticism is being encountered from commercial lighting and power consumers that the average domestic rate is unjustifiably low in comparision with the rate for these other classes of service, and it is possible that further justification of the residential combination rate should receive attention by a future committee.

# Engineering Section Report*

THE Engineering Section has been particularly active during the current year. Considerable progress has been made, particularly in the radio interference research being carried on by Prof. F. O. McMillan under sponsorship of the inductive co-ordination committee, and in the fishway experiments by the hydraulic power committee.

In addition, some study was devoted to the engineering features of the proposed change from the present Washington state overhead line construction regulations to the National Electrical Safety Code.

Also, the engineering features in the proposed new interior wiring code for the State of Washington were studied.

Close contact was maintained with the Engineering National Section, and several delegates from this section attended both the Montreal and St. Louis meetings.

The annual meeting of the section was held in Wenatchee, Wash., March 18-20, 1931. At this meeting 27 papers were presented and discussed. Through the courtesy of the Stone and Webster organization, the Puget Sound Power & Light Company, and The Washington Water Power Company, particularly interesting inspection trips were furnished to the Rock Island development on the Columbia River, and the Chelan development of The Washington Water Power Company on Lake Chelan.

## Committee Activities

The following subjects comprise the larger part of the year's work and were presented in final report form at the March meeting.

*Underground Systems Committee—C. H. Hoge, chairman.*

Latest Practices in 66-kv. Underground Construction, by F. E. Fisher, Puget Sound Power & Light Company.

A.C. Network System in Portland, by S. B. Clark, Northwestern Electric Company.

*Electrical Apparatus Committee—J. Hellenthal, chairman.*

Metal Clad Switchgear for Indoor and Outdoor Applications, by J. C. Henkle, Portland General Electric Company.

Analysis of Distribution Substations up to 10,000-Kva. Capacity, by A. Shipek, Puget Sound Power & Light Company.

Quick Response Excitation and High Speed Relays, by Richard McKay and C. E. Cannon, The Washington Water Power Company.

*Progress Reports in Synopsis Form—*

(*a*) Special Transformers for Use With 2.3-Kv. Regulators on 11-Kv. or 15-Kv. Systems. Application of Single Bushing Type Transformers for Rural Substations, by E. A. Woodhead, Idaho Power Company.

(*b*) Load Ratio and Phase Control of Transformers. Automatic Load Response Switching of Station Transformers Serving Distribution Feeders, by D. R. McClung, Pacific Power & Light Company.

(*c*) Study of Recent Data Obtained from Transmission Surges, by George McClellan, Mountain States Power Company.

(*d*) Operation of Rotating Machines by Total Temperature, by D. L. Brundige, Utah Power & Light Company.

(*e*) Study of Bushing Type Capacitors and Their Application, by F. M. Lewis, Northwestern Electric Company.

(*f*) Substation Grounds. A Brief Survey of Experiences in the Northwest, by A. H. Beckwith, The Washington Water Power Company.

*Hydraulic Power Committee—E. H. Collins, chairman.*

Progress Report on Fishways, by J. E. Yates, Pacific Power & Light Company.

Rock Island Project, by W. D. Shannon, Stone & Webster Engineering Corporation.

Relation of Tree Rings to Climatic Cycles, by Lyman Griswold, Consulting Engineer, Northwestern Electric Company.

Automatic Frequency and Load Control, by J. S. McNair, The Washington Water Power Company.

*Code Committee—S. B. Clark, chairman.*

Decreasing Cost of Wiring in Dwelling Occupancies Without Sacrificing Adequacy, by L. W. Going, Chief Electrical Inspector, Portland, and F. D. Weber, Oregon Insurance Rating Bureau.

*Overhead Systems Committee—T. A. Purton, chairman.*

Progress Report of the Overhead Systems Committee, by T. A. Purton, Idaho Power Company.

Design and Construction of Recent 110-Kv. Transmission Lines.

(*a*) Rock Island, by T. H. Campbell, Stone & Webster Engineering Corporation.

(*b*) Ariel, by B. H. Aaron, Northwestern Electric Company.

Economic Rural Line Construction, by D. S. Young, Young Electric Company.

*Meter Committee—A. H. Kreul, chairman.*

Meter Committee Reports, by A. H. Kreul, Portland General Electric Company.

Recent Developments, by L. H. Kistler, Northwestern Electric Company.

Short Courses for Metermen, by Prof. R. H. Dearborn, Oregon State College.

*Inductive Co-ordination Committee—H. H. Schoolfield, chairman.*

Radio Interference from Pin Type and Pedestal Type Insulators, by Prof. F. O. McMillan, Oregon State College, and Ellis Van Atta, Pacific Power & Light Company.

* Executive Committee: E. F. Pearson, chairman; E. H. Collins, vice-chairman; D. W. Proebstel, P. P. Ashworth, H. H. Cochrane, R. S. Daniels, W. S. Hill, O. L. LeFever, O. D. Lanning, Z. E. Merrill, G. E. Quinan, M. V. Watson, J. E. Yates, J. B. Fisken, S. B. Clark, J. Hellenthal, H. H. Schoolfield, A. H. Kreul, T. A. Purton, C. C. Simeral, C. H. Hoge.

Symposium of Current Cases of Inductive Co-ordination between Power and Communication Systems, by H. H. Schoolfield, Pacific Power & Light Company.

*Accident Prevention Committee—J. B. Fisken, chairman.*

Classification of Employees to Locate Accidents, and Accident Experience of Member Companies, by Wallace Brier, Puget Sound Power & Light Company.

The Hay Derrick Hazard, by E. C. Kiersted, Idaho Power Company.

The Use of Mechanical Devices in Artificial Respiration, by Walter Smith, Mountain States Power Company.

*Prime Movers Committee—C. C. Simeral, chairman.*

Obsolescence Relating to Steam and Hydro Development, by A. H. Greisser, Portland General Electric Company.

# General Committee Report

## *Educational Committee**

ENROLLMENT in N.E.L.A. educational courses in the Northwest Geographic Division in the twelve-month period ending March 31, 1931, as compared to the enrollment for the previous twelve-month period was as follows:

| | 1931 | 1930 |
|---|---|---|
| Practical Electricity | 20 | 51 |
| Elementary Accounting | 11 | 11 |
| Advanced Accounting | 3 | 32 |
| Lighting Sales | 6 | 5 |
| Merchandising Sales | 5 | 14 |
| Power Sales | 4 | 10 |
| A.C. Meter Course | 6 | 21 |
| D.C. Meter Course | 1 | |
| Appliance Course | 9 | |
| | 65 | 144 |

The current year's enrollments were divided among companies as follows:

| | |
|---|---|
| Idaho Power Company | 32 |
| Eastern Oregon Light & Power Company | 15 |
| Northwestern Electric Company | 4 |
| Puget Sound Power & Light Company | 4 |
| The Washington Water Power Company | 3 |
| Portland General Electric Company | 2 |
| Utah Power & Light Company | 2 |
| The California Oregon Power Company | 1 |
| Mountain States Power Company | 1 |
| Pacific Power & Light Company | 1 |
| Total | 65 |

The new "Electric Service Salesmanship-Appliance" course has been added during the past year to the other courses already offered. This course costs $25 to $29, depending upon whether or not the student elects to take all or only a part of it. It is one of the most complete and comprehensive commercial courses yet to be offered by the N.E.L.A. educational committee.

An outline of its scope is as follows:

ELECTRIC SERVICE SALESMANSHIP APPLIANCE COURSE

*Required*

I. The Salesman and His Work
II. Field Selling—(*a*) Prospecting for New Business
III. Field Selling—(*b*) The First Few Minutes—and After
IV. Field Selling—(*c*) Overcoming Obstacles and Closing
V. Building a Sales Personality

*Elective*

A choice of seven, eight, or nine of the following may be made when enrolling:

VI. Selling in the Show-Room
VII. Selling Electric Refrigeration
VIII. Selling the Electric Home Laundry
IX. Selling Vacuum Cleaners
X. Selling Table and Small Appliances
XI. Selling Electric Health Appliances
XII. Selling Ranges and Hot-Water Heaters
XIII. Selling Radios
XIV. Selling to the Rural Customer

* Report of the educational committee, general committee reports, Berkeley Snow, Electrical West, chairman.
The California Oregon Power Company: H. L. Bromley.
Eastern Oregon Light & Power Company: B. F. Lentz.
Idaho Power Company: E. C. Kiersted.
Mountain States Power Company: Z. E. Merrill.
Northwestern Electric Company: R. W. Faville.
Pacific Power & Light Company: G. T. Bragg.
Portland General Electric Company: G. E. Sullivan.
Puget Sound Power & Light Company: H. G. Winsor.
Utah Power & Light Company: M. L. Cummings, Jr.
The Washington Water Power Company: W. H. Ude.
West Coast Power Company: J. B. Brokaw.